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RAYMOND OLNEY
Editor and Business Manager

EDITORIAL

Example of Productive Research

SELDOM has the development of any one new unit of equipment met with such widespread favorable interest as the Michigan radiant-energy frost controller. It offers some lessons in viewpoint, opportunities, technology, and procedure in agricultural engineering.

A leader in agriculture, with more than ordinary appreciation of engineering as a technology capable of helping farmers, suggested frost control as a field of investigation. It was one specific opportunity to help Michigan farmers alone to reduce a 20 million dollar annual loss if it could be worked out.

Arthur W. Farrall and some of his associates in the department of agricultural engineering at Michigan State College approached the problem from a research viewpoint. They collected all the data they could find on types and causes of frost, rates and nature of heat losses from soils, rates of transfer of heat from lower layers to surface soil, and existing means of frost control.

They found that frosts were commonly caused by radiation of heat from the soil, and that existing means of heating the air over a field involved prohibitive costs and other serious disadvantages in all but exceptional cases. They considered replacement of heat by radiant energy. It was not a principle already in common application by agricultural engineers. But it was a well-established principle in the science of physics, being applied in some other branches of engineering, and available for consideration.

The mechanics of heat source, reflection, and mounting were worked out, some models built, and preliminary tests made. Results were encouraging. Refinement became a matter of further research and testing.

Opportunities and objectives for agricultural engineering research are indicated by the whole range of economic and social losses in farm activities due to adverse weather, chemical conditions, parasitic and competing organisms, fire and other physical disaster, and the limitations and competing activities of man. They are indicated further by positive concepts of new ways and means, new forms of production and service, new ways of living to increase the net production by agriculture of genuine human values.

The technology to be applied in agricultural engineering research is not limited by what has already been applied. The whole range of physical science is potentially available. The physical science already in use in some one or more branches of engineering may indicate some of the more apparent opportunities. The physical science to be brought to bear in any particular case will depend on the most accurate analytical definition of the problem or problems that can be made from existing information.

The Customer Factor in Business

A TREND of thought in responsible business administration, toward increasing recognition of the buying power factor in an economy of free enterprise, is indicated in a recent quotation from Fowler McCormick. Said Mr. McCormick, in part, ". . . the time is here to recognize customers as an integral part of a business. Our present wage-price-profit mechanism is out of date. All industry finds itself in the same situation. . . . . We have done something for our stockholders, ... and we have done plenty for our employees. Now we must try to be equitable in our treatment of the third group — our customers." This was in reference to a price reduction which represented a substantial token increase in customer buying power.

Here we have a concept of equity which may be broader than it appears at first glance. It suggests a picture of a free economy as a mechanism in which buying power is the fuel which turns the wheels, and which must be replenished by their turning. More specifically it suggests a balancing relationship in which the proportion of national income going into consumer purchasing power is the only weight at one end of the scale which can support and maintain at the other end the value of the remaining income saved and invested in new production.

If this is true, the equity of which Mr. McCormick speaks is the combined equity of customers, employees, stockholders, engineers — in fact, everyone in the balanced, productive operation of our economic mechanism.

Physical Properties of Agricultural Materials

ONE of the remaining blanks in the scientific knowledge frequently needed by agricultural engineers is in the physical properties of agricultural materials.

We suggest the development and compilation of more of this basic knowledge as a logical job for publicly supported pure science research.

It will involve a lot of onerous detail, with little prospect of direct reward in terms of fame or fortune. Unless some department of agricultural physics can be found to do it, some agricultural engineers with inclination toward pure science may have to do it, to a greater extent than they have in the past.

The agricultural materials we have in mind include the various crop plants, livestock, and pest organisms and their separate parts, in various stages of their life cycles, together with their environmental soil, water, and air.

The physical properties we have in mind include not only their dimensions, shapes, proportions, internal structure, density, strengths, and kindred characteristics, but their electrical and acoustical properties; and the manner and extent of effects produced by environmental physical influences of temperature, pressure, light and other spectral energy, electricity, and other forces, as they occur in nature or might be applied by man.

Physical science has served long and faithfully as the chore boy of agricultural commerce, measuring and recording common sizes, strengths, densities, and a variety of other properties relating to existing uses of a wide range of organic materials, from cotton fiber to heavy timber.

But pure science has also shown a greater field of usefulness. It has proven the long-range economy of producing a stockpile of knowledge to be drawn on by business as practical uses become evident. It has shown that both the processes and the results of searches for new knowledge often suggest valuable uses, new opportunities, new approaches, which do not come to light when science is limited to service as a chore boy.

On this stockpile of knowledge, information on the physical properties of agricultural materials is a primary substance for use by agricultural engineers, to create new and improved engineering tools and processes for use by farmers. It is to our interest to strongly encourage the development of this information.

AGRICULTURAL ENGINEERING

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Negative Radiation—Its Relation to Farm Building Design

By S. Milton Henderson
Member A.S.A.E.

THE study reported in this paper developed out of some observations of the temperature effect of white paint on sheet metal roofing. Sheet metal as a roofing material is criticized because it and the space under it becomes hot due to the heat energy received from the sun. This condition can be corrected by insulating the roof or by providing an outer surface which reflects a large part of the solar heat. Since white is known to be a good excluder of solar heat and since bright metals are known to be better excluders than dull metals, the quantitative effectiveness of white-painted, new galvanized, and weathered-galvanized surfaces was observed in the following manner.

Three tight, well-insulated compartments (Fig. 1) were covered with uninsulated corrugated sheet metal roofs. The roof of one compartment was well-weathered sheet metal seven years old. The second compartment was covered with new galvanized sheet metal, and the third with white-painted sheet metal. Previous tests of solar reflectivity of these surfaces showed that the old galvanized sheet absorbed about 90 per cent of the impinged normal solar radiant heat energy, the new sheet approximately 72 per cent and the white-painted sheet about 45 per cent[3]*. The greater the absorptivity, that is, the amount of solar heat that gets into the building (is not reflected), the hotter will become the surface and the space underneath. One would conclude from this that the older sheet and its corresponding compartment would be hotter than the newer sheet at times when the sun was shining. But this was not the case. Tests were made on four different days with bright sun and a clear sky and in each case the newer sheet and its corresponding compartment was hotter than the older sheet and its compartment. A representative temperature chart showing both surface and compartment temperature for one day is shown in Fig. 2.

The amount of radiation normal to the roof was secured by an Eppley pyrheliometer and a Micromax recorder made by the Leeds and Northrup Co.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June 1946, as a contribution of the Farm Structures Division. This paper is also designated as Journal Paper No. J-1386 of the Iowa Agricultural Experiment Station, Project 562, in cooperation with the Republic Steel Corporation.

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*Superscript numbers refer to appended references.

Fig. 1 This picture shows the test house used for the temperature studies reported in the accompanying paper

Roof and compartment temperatures were observed by thermocouples. Note that both the roof and compartment temperature of the new sheet were greater than those of the old sheet for the entire day, a condition which existed during the four-day period. Note also that the white surface reduced the temperature elevation above air temperature to approximately half that for the galvanized sheets. The new sheet reached a temperature of 149 F (degrees Fahrenheit), 60 F above air temperature. The maximum for the white sheet was 115 F, only 26 F above the air temperature. Although not directly related to the problem at hand, this observation should be of considerable interest to those who want to maintain cool structures in summer. For example, white paint has been used effectively to reduce summer temperatures in grain bins. After checking the temperature observing equipment for possible errors and finding none, it was conceived that variation in the rate of negative or outward radiation from the roof to the sky between the two galvanized sheets might cause this apparently illogical phenomenon.

Negative Radiation. Negative radiation, so-called, is the loss of heat from the earth to the sky by radiant heat exchange and is the phenomenon which produces dew, frost, and unusually cold nights when the sky is clear. The general aspects of this are shown by the Stefan-Boltzmann equation[3] which is

$$Q = 0.173 \times 10^{-8} E \,(T_1^4 - T_2^4).$$

This gives the net radiant heat exchange in Btu/sq ft/hr between two bodies whose absolute temperatures are T_1 and T_2 and whose effective emissivity is E. Emissivities are expressed as fractions of the rate of radiation for a perfect black body. For instance, white paint has a factor of about 0.90, fairly bright galvanized sheet metal, 0.23, and oxidized and dirty sheet metal, over 0.30[4]. The variation between the two sheet metal indices was conceived as a possible cause for the results indicated above.

The rate of loss from a roof to the sky varies directly as the emissivity of the roof surface and increases as the fourth power of the absolute roof temperature. The loss could be calculated from any known condition if the effective sky temperature, T_2, were known. Unfortunately the factors which contribute to this value are so complicated and involved, no simple method of calculation is possible[6]. Because of this complication an entirely different method of approach was made.

The effect of this negative radiation feature was investigated, first by suspending pieces of sheet metal about 10 in square with thermocouples soldered underneath, under the open sky on a clear night and noting the temperature depression, that is, the number of degrees the sheets dropped below air temperature. Four different surfaces were used. The observations are reported in Table 1. Note that the black, white, and old galvanized sheets were about 12 F lower than air temperature during the entire period and that dew formed shortly after the test began. The new galvanized sheet dropped only 8 F, a value which was constant for most of the period. Dew formed much later on the new than on the other sheets. This shows definitely that the new galvanizing radiates at a slower rate than the other three surfaces. The greater the temperature differences, the faster the radiation. This is shown quantitatively later in this paper. This indicates that the performance of the roofs under sunshine conditions was no doubt correct and that variation in the rates of outward radiation between the two galvanized sheets produced the interesting results shown in Fig. 2.

TABLE 1. TEMPERATURE DEPRESSION OF STEEL SHEETS WITH VARIOUS SURFACES DUE TO NEGATIVE RADIATION ON A STILL NIGHT

Time (p.m.)	Air temp., F	Temperature depression of sheets* White painted	Black painted	Old galv.	New galv.	Dew on sheets
7:00	47	15	15	14	9	Little to none
7:25	45	13	13	12	9	All covered except new
7:45	44	13	12	12	8	"
8:15	43	11	11	11	8	"
8:35	42	12	10	10	8	"
9:05	42	12	11	12	9	"
10:00	42	12	12	12	10	Trace on new
10:40	42	11	12	11	12	All covered

*Difference between air temperature and sheet temperature.

A heat balance of these compartments would have helped to analyze the problem but this was not possible because the solar absorptivity appears to increase as the angle of incidence increases. This, and the complications resulting from the use of corrugated rather than flat sheets, did not permit an accurate value of the absorbed radiant energy to be secured for the periods studied.

Indicated Rates of Loss by Radiation. The magnitude of the loss by radiation was investigated by additional controlled tests and review of published material relative to the problem.

Electric heaters, thermostatically regulated to produce a continuous compartment temperature of about 80 F were placed in each of the test compartments discussed above and the electrical energy metered. A 21-day series of tests were made during the winter, and the following data were taken: continuous record of air temperature, average wind velocity and direction for each 24-hr period, and heat input per compartment per 24-hr period. Since no direct solar radiation hit the north compartment and since the indirect radiation was probably small, a daily heat balance was made for each north compartment. The difference between the heat input and that lost by conduction to the outside air was assumed to be loss by radiation. The average indicated rates of radiation for the old galvanized, new galvanized, and white-painted sheets were 10.0, 6.5, and 27.0 Btu/sq/hr, respectively. The published emissivity coefficients for these surfaces are 0.276, 0.228, and 0.94, respectively[4]. Dividing the rates by the respective emissivity values, the basic or black body (emissivity, 1.00) radiation values are 35.2, 28.5, and 28.7 Btu/sq ft/hr, respectively. The old galvanized sheet used for testing was unusually dark and dirty because of proximity to a railroad. It would be expected that its emissivity would be higher than that of a normally aged sheet because of this. Considering this condition, it is entirely probable its value could have been, say, 0.35, rather than 0.276. This would bring the basic radiation value in line with the other two and the close agreement would indicate that these are definite and, perhaps, significant indices.

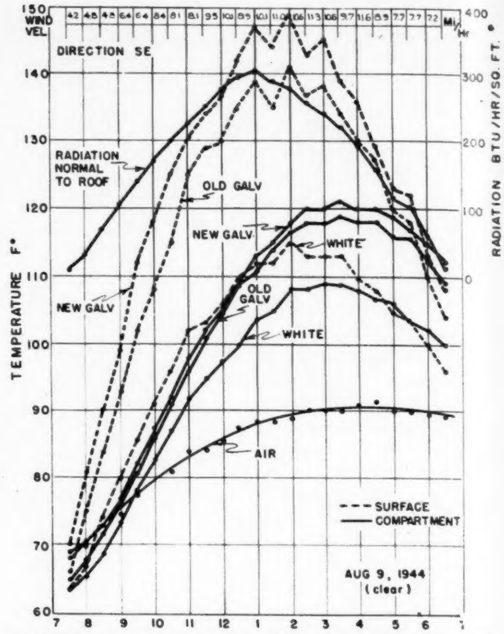

Fig. 2 Temperature observations of white-painted, new galvanized and old galvanized sheet metal roofs and compartments

The steel sheets exposed at night and reported in Table 1 radiated according to the following formula:

$$Q_R = \frac{CA}{E}(t_a - t_s)$$

Q_R is the rate of radiation loss from the surface to the sky, expressed in Btu per hour per square foot of exposed surface. C is the surface conductance coefficient which varies with the wind velocity, Btu per square foot per hour per degree (F) difference in temperature. A is the area exposed to the wind per square foot of radiating surface. t_a and t_s are air and surface temperatures, respectively. The surface temperature can go but little lower than the atmospheric dew point. When the dew point is reached, the heat energy which is radiated is that liberated, at least in part, by the condensing water vapor. C for still air is 0.95 and both sides of the sheet were exposed to the air, so A is 2. E for the white and black surface is assumed to be 0.94, the old galvanized surface 0.35, and the new galvanized surface 0.228. Q for these four surfaces, based upon the 7:00 p.m. observation, when there was little dew formation, would be 30.3, 30.3, 74.0, and 74.6, respectively. It is apparent that the last two values are in error. A thin film of water would alter the coefficient of the last two and could easily produce the results shown. Since the coefficient for water is about the same as for black and white-painted surfaces, it is probable that the first two values are fairly reliable, but the third and fourth should be disregarded. Radiation between the sheets and the ground may have produced a small but probably unimportant error.

Similar observations by the U. S. Bureau of Standards indicated a depression of 13 F for panels covered with house paints[2]. Although there was no indication of wind conditions, the rate of radiation could not have been less than 24.7 Btu, the rate for a null wind.

Observations of night radiation at Fairbanks, Alaska, and Fargo, N. D., by the U. S. Weather Bureau during clear weather gave values ranging from 4 to 30 Btu[5].

The basic negative radiation values from the four sources discussed above indicate that a value somewhere around 25 Btu/sq ft/hr would be a fairly representative average value for clear weather conditions. This value which is known to vary considerably even on a clear night due to moisture content of the air and thickness of air layer may or may not be significant, but will be used during the discussion which follows. Even though it may not be accurate, it will demonstrate the implications of this factor which is usually overlooked in design calculations.

Importance of Negative Radiation in Design. The negative radiation factor can be incorporated in the design procedure by the formula in Fig. 3. This formula assumes steady state conditions and a basic negative radiation value of 25 Btu/sq ft/hr. Since constant flow is assumed, the heat supplied inside the structure, Q, must pass through the walls. This takes place because the temperature of the outside surface, t_s, is lower than the inside air temperature, t_i. Transfer of the heat from the inside to the outside surface is represented by the middle unit of the formula, $U'(t_i - t_s)$. The heat passes from the surface outward by radiation, $25E$, and by conduction to the air, $C(t_s - t_a)$. The division of the dissipated heat between these two depends upon the surface emissivity, the wind velocity, and temperature difference $(t_s - t_a)$.

This formula can be used for any conventional design problem by substitution. But since it must be solved for t_s and U' must be determined during the solution, a more simplified method was desired. Simplification was secured and the importance of negative radiation was demonstrated by comparing heat requirements for certain conditions if negative radiation is considered with that indicated as required if it is not considered. The procedure for this follows:

$$25E + C(t_s - t_a) = U'(t_i - t_s) = Q$$

$$\text{Let } t_i - t_a = \Delta t$$

$$t_i - t_s + t_s - t_a = \Delta t$$

$$\therefore t_s - t_a = \Delta t - (t_i - t_s)$$

By substitution

$$25E + C\Delta t - C(t_i - t_s) = U'(t_i - t_s)$$

$$25E + C\Delta t = (C + U')(t_i - t_s) \qquad [1]$$

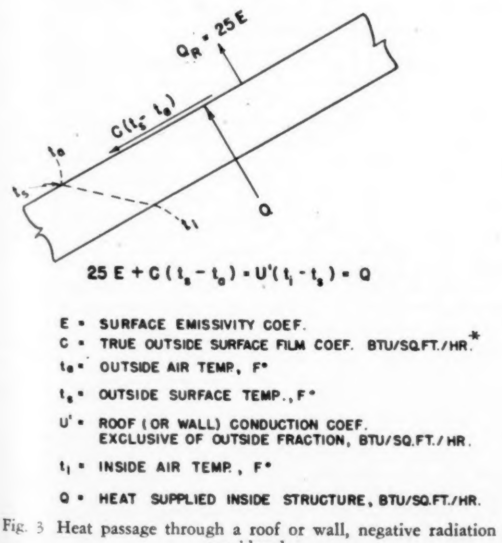

Fig. 3 Heat passage through a roof or wall, negative radiation considered

If radiation is neglected for any condition, the $25E$ term will drop out. The surface temperature will change to t_{sn}, the subscript $({}_{sn})$ indicating surface temperature with radiation neglected or zero. Then

$$C\Delta t = (C + U')(t_i - t_{sn}) \qquad [2]$$

Dividing equation [1] by equation [2]

$$\frac{25E + C\Delta t}{C\Delta t} = \frac{(C + U')(t_i - t_s)}{(C + U')(t_i - t_{sn})} = \frac{(t_i - t_s)}{(t_i - t_{sn})}$$

Introducing U' and then Q,

$$\frac{25E + C\Delta t}{C\Delta t} = \frac{U'(t_i - t_s)}{U'(t_i - t_{sn})} = \frac{Q}{Q_n}$$

$$\therefore Q = Q_n\left(\frac{25E}{C\Delta t} + 1\right)$$

Let

$$\left(\frac{25E}{C\Delta t} + 1\right) = F$$

$$\therefore Q = Q_n F$$

F is a correction factor which can be applied to heat requirements determined by conventional calculations to correct for negative radiation. Q equals the over-all coefficient, U, times the difference between the inside temperature and the outside temperature. This is the conventional method of calculation. Values secured in this manner times F will give the heat requirement if negative radiation is considered.

The relationship between F, C, E, and t is shown nomographically in Fig. 4.

This chart serves two purposes. It may be used for securing design data, and it demonstrates the error which may result if negative radiation is not considered when designing a building. The use of the graph and the implications of the radiation factor can best be demonstrated by taking a problem and considering it from a number of different angles.

A roof has a thermal coefficient of 0.30 based upon a 15-mph (mile per hour) wind and, being of painted wood construction, an emissivity coefficient of about 0.92. How much heat is required per square foot of surface if an inside tem-

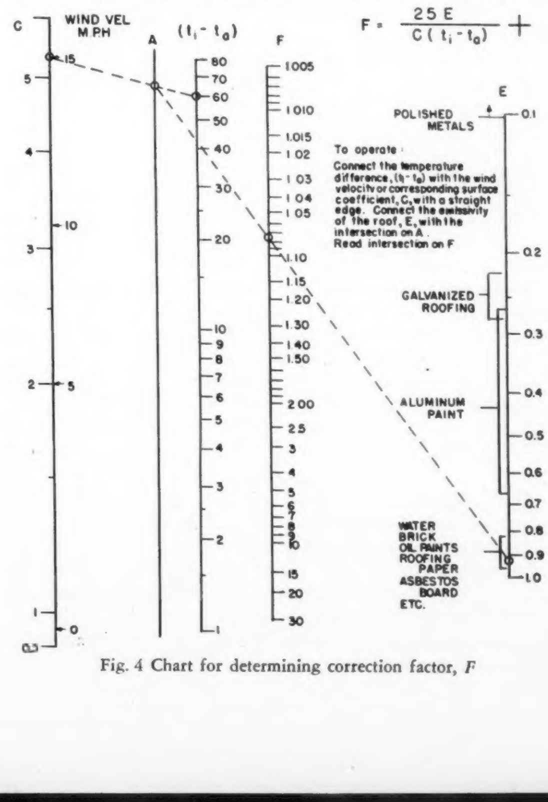

Fig. 4 Chart for determining correction factor, F

perature of 60F is required for zero outside? The thermal coefficient of 0.30 times the temperature difference, 60F, indicates that 18 Btu are required per square foot per hour. This is the conventional method of determining heat requirements. F from Fig. 4 for E of 0.92, a 15-mile wind and a 60-F differential is 1.075. Therefore, the heat requirement would actually be 1.075 times 18, or 19.35 Btu. This indicates an error of 7½ per cent.

Suppose the same conditions exist after the structure has been built but on a certain night the wind doesn't blow. If the thermal coefficient is 0.30 for a 15-mph wind, the same wall or roof would have a coefficient of 0.24 for a null wind because of a reduction in the outside coefficient. This value times the temperature difference would be 14.4 Btu/sq ft/hr. The F factor for this condition would be 1.40, which, times 14.4 would be 20.1 Btu/sq ft/hr actually required to maintain the required 60-F differential. The error in this case would be 40 per cent. This is greater than the requirement when a 15-mph wind is considered, an observation which should be noted with more than a passing thought.

The effect of a roof of low emissivity, galvanized sheet metal, for example, can be demonstrated by considering the above problem with no wind and an E of 0.25, F is found to be about 1.11 rather than 1.40, the heat requirement 16 rather than 20.1 Btu. Thus it is shown that a roof (or wall) with a low emissivity is an effective heat conserving medium.

Consider a poultry house with walls of such construction that no heat is lost through them, either by conduction or radiation. It is desired to maintain an inside temperature of 40F for zero outside using the sensible heat produced by the birds. What roof construction would be used if the emissivity is 0.92?

A chicken produces about 46 Btu/hr[1]. On the basis of 4 sq ft per bird this would amount to about 11 Btu/sq ft/hr for the ceiling. The over-all coefficient, U, would be 11 divided by 40 or 0.275. For these conditions, note from Fig. 4 that F is 1.65. This means that with the roof indicated, 65 per cent more heat would have to be supplied to maintain the desired inside temperature under negative radiation conditions. The actual conditions which would exist if no heat were supplied can be determined by substitution in the formula of Fig. 3 and solving for t_s and t_1. U for a null wind would be 0.386. The surface temperature is found to be 13F below zero and the inside temperature 15½F rather than the desired 40F. What would happen under the same conditions if the roof were covered with galvanized sheet metal (E=0.25)? The outer surface is found to be 5F above zero and the inside, 34F.

These values would probably not apply accurately for walls since a wall "sees" the ground as well as the sky. Some reduction in the radiation rate would be expected because of this. No attempt was made to determine this factor but it should be recognized as existing.

This problem further demonstrates the error which may result by neglecting negative radiation when designing on the basis of a constant heat source and shows the importance of an outer surface with a low emissivity.

Building designers who have been unable to account for the excessive heat loss from carefully designed buildings during certain winter periods may find an answer in a study of negative radiation.

SUMMARY

This analysis was intended primarily to demonstrate the importance and possible implications of negative radiation as a design factor. It is recognized that the quantitative features of the problem are not well defined and a number of carefully controlled tests should be made to check the procedure and relative performance herein propounded. In spite of the admitted uncertainties of some of the features of this analysis, certain facts do stand out.

1 Negative radiation on a clear night appears to be about 25 Btu/sq ft/hr for a black body. The accuracy of this value should be verified and the factors which affect it evaluated.

2 Negative radiation is of little consequence under conditions of high wind and large inside and outside temperature differentials. For low wind velocities or small temperature differentials, or both, considerable error may result if it is disregarded.

3 If outside surfaces with a low emissivity are used, the effect of the negative radiation factor is minimized. Galvanized sheet metal is an excellent surface to use in this respect.

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Ag Engineers Shine in Virginia Farm Electrification

TO THE EDITOR:

I HAVE read with a great deal of interest the article, entitled "Electrification through Agricultural Engineering" on page 13 of AGRICULTURAL ENGINEERING for January. The Mississippi Power and Light Company is to be congratulated on the progressive program it has launched to electrify its rural territory, and to cooperate with farmers, rural groups, and educational agencies in promoting sound agricultural practices. Both the company and the rural people it serves should benefit from such a program.

In fairness to the electric utilities and electric cooperatives operating in Virginia, I would like to point out that programs of this type have been in operation in Virginia for many years. One of our leading utilities employed an agricultural engineering graduate of Virginia Polytechnic Institute in 1928, and he developed a very successful educational program. That company soon employed additional agricultural engineers and the other large utilities operating in Virginia followed suit. Since the beginning of this movement in the state in 1928, these two utilities have progressively and systematically expanded their educational work, employing agricultural engineers to handle this activity. At the present time, the utilities have 21 and the electric cooperatives employ 7, making a total of 28 agricultural engineers with the electric service organizations in Virginia. All of these men have college degrees in agricultural engineering, and are usually given the title of "agricultural engineer" by their employers. These organizations also have other personnel in the field doing rural electrification work, but they are designated as "rural service engineers" or "rural representatives".

The cooperative efforts of these electric service organizations, the Virginia Polytechnic Institute, and other agencies over this long period of years has culminated in the organization of the Virginia Farm Electrification Council.

It might be of interest to note that our agricultural engineering curriculum at Virginia Polytechnic Institute has stressed training in rural electrification for a number of years. We are strengthening and enlarging this type of training as rural electrification is one of the important fields of employment for our graduates. Of some 240 agricultural engineering graduates of Virginia Polytechnic Institute, approximately a fourth are employed in rural electrification activities with electric service organizations, REA, TVA, USDA, and state colleges in extension, research, and teaching.

We believe that men with a farm background and agricultural engineering training secured through a recognized four-year college course in agricultural engineering have the ideal basic qualifications for doing rural electrification work. Unfortunately some utilities are employing men who have had various types of agricultural training and experience but who are not trained engineers to do rural electrification work, and they are calling them "agricultural engineers". This practice is obviously unfair to men who are qualified agricultural engineers by training and profession. I feel that the American Society of Agricultural Engineers should note the increased misuse of the title "agricultural engineers" and take some official action to curb it. It seems to me that action is essential in order to carry out the object of the Society as set forth in Article C2, Section 1, of the Society's constitution.

Head, agricultural engineering dept., Virginia Polytechnic Institute

CHAS. E. SEITZ

Relation of Time and Operating Schedule to Hay Quality, Mold Development, and Economy of Operation

By C. W. Terry
MEMBER A.S.A.E.

FOR generations hay has been one of the most important crops in New York state. Farmers are always anxious to harvest this crop and get it into storage in the best possible condition. A great variety of harvesting methods have been used and many different ones are being used at the present time. Artificial curing methods have been tried with more or less success for about 35 years.

With more and more emphasis being placed on mechanization of farm tasks, perhaps we should reconsider the basic factors influencing the economics of haymaking. When ideal weather conditions prevail, it is generally conceded that almost any farmer can make good hay. But it is also true that the best farmers have difficulty saving a crop when weather conditions are unfavorable at a time when the hay is at the proper stage for cutting.

Let us first consider what conditions are necessary in order to assure good quality. B. A. Jennings (Cornell University) found as a result of his bin tests that hay, the moisture content of which was reduced below 20 per cent in not more than 3½ days, had good quality and was free from visible mold. These tests were made with small variations in the environmental conditions, i.e., normal weather for the time of the tests. Consider now what happens if some other conditions are produced artificially.

Fig. 1 gives an idea of the effect of temperature on the time required for visible mold to form on hay. This curve applies only to hay of high moisture content. It should be noted that change of moisture content has an effect similar to that which results from change of temperature, i.e., as drying progresses the time required for mold growth increases. The curve indicates that when the temperature of the hay is from 80 to 90F (degrees Fahrenheit) the drying process must be completed in less than two days if mold is to be avoided. A test was made by the agronomy department of Cornell University (June, 1946), starting with baled hay having about 65 per cent moisture. This hay was put on a duct system and air at about 140F was applied from a furnace. Air leaving the hay had a temperature in the range of most rapid mold growth and since drying was not complete in two days, a large amount of mold resulted. With temperatures greater than 100 F or less than 70F the allowable time for curing increases rather rapidly.

We recognize that low temperatures prevent spoilage in the case of most food products. Therefore, one could conclude that hay of high moisture content might be kept in cold storage; however, the value of the crop would not justify such a procedure. Temperatures greater than 120F kill most molds, therefore heat may be used to prevent their growth. However, in order to have a temperature this high while evaporation is in progress, there must be a much higher inlet air temperature (approximately 290F). This results in complex problems of construction and operation, as well as in reduced thermal efficiency. For these and other reasons the high-temperature dehydrator is not likely to come into common farm use.

The bacteriologists tell us that we may prevent mold by subjecting the hay to a temperature greater than 125F for a short time only. Perhaps we should design a hay pasteurizer. If so, we should go all the way and use a temperature that will kill the bacteria, too, and thus reduce the respiration losses. But again it is doubtful whether such a process would be economical.

Field curing should be used as far as possible. In order to remove the moisture from hay, heat must be supplied for its evaporation. Regardless of the source of heat, about 1000 Btu are required to evaporate each pound of water.

To reduce the original moisture content of hay from various percentages to that necessary for safe storage requires removal of water in amounts shown by Fig. 2.

It is interesting to note that reducing the moisture content from 75 to 60 per cent requires removal of as much water as is required to reduce it from 60 to 15 per cent. Unless there is possibility of considerable loss from rain, it is best to allow hay to cure in the field to at most 35 to 40 per cent moisture content. During the early part of the summer (early June) it is difficult to judge the most economical time to put hay on a mow-curing system. In fact, there is good evidence to show that it is best to put this early cut crop in the silo. A few weeks later in the season field curing accomplishes results economically in most cases. Prolonged periods of rainy weather

This paper was presented at the Third Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Chicago, Ill., December, 1946.

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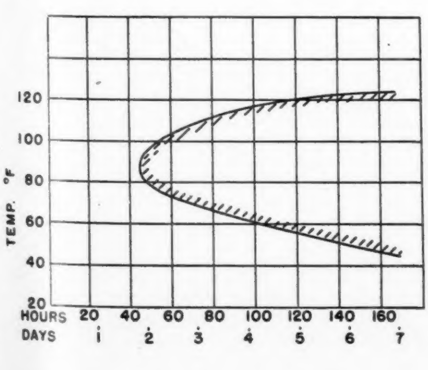


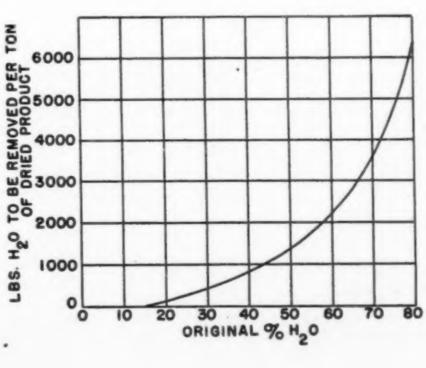


Fig. 1 *(Left)* The effect of temperature on the time required for the formation of visible mold on hay • Fig. 2 *(Right)* The weight of water that must be removed to reduce the moisture content of hay to 15 per cent

or unusual labor situations may change the situation to such an extent that a greater expenditure for power and heat may be justified.

Load the mow finishing system frequently. In using a mow curing system the question arises as to whether it is best to load it every day or as often as possible with small quantities of hay or to load it with larger quantities at less frequent intervals.

Test results and theory indicate that the efficiency of the system will be improved if small quantities are loaded at frequent intervals.

As the moisture content of the hay decreases, the rate at which water evaporates from the stems and leaves also decreases. This is illustrated graphically by the curves of Fig. 3. All the curves show a rapid decrease in the evaporation rate as the moisture content is reduced. They show that the rate is greater during the day than at night. Also, a marked increase in evaporation rate can be obtained by use of supplementary heat.

One concludes then that, if hay is put on a system in small quantities and at frequent intervals so that the top layer has high moisture content, the operating efficiency will remain high. Experience has taught that much power is wasted if dry spots occur before the moisture content of the remainder is low enough for safe keeping.

Location of the air intake for hay driers. It is stated in TVA Agricultural Engineering Publication No. 6 (Barn Haydrier Design Installation and Operation) that "There is ample heat from the sun to furnish an adequate supply for a hay drier. In the Tennessee Valley area between the hours of 8 a.m. and 5 p.m. on a clear day in August the sun supplies an average of 216 Btu an hour to each square foot of the earth's surface. It varies from 151 Btu at 8 a.m. to a maximum of 298 Btu at noon, and back to 72 Btu per hr per sq ft of surface at 5 p.m. The problem is to collect this heat and transfer it to the air used in hay drying. It is a case in which the supply is free but the cost of utilizing is high."

Tests were made to determine the variation in temperature and relative humidity on the four sides of the agricultural engineering laboratory building at Cornell University during the second week in August, 1946. On cloudy days there was little or no difference between the readings of the four hygrothermographs. At night there appeared to be some difference, due probably to the wind direction and radiation of heat stored during the day.

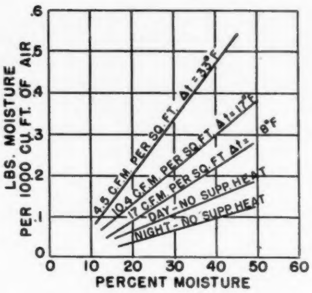


Fig. 3 Effect of moisture content of hay on the rate at which further removal of moisture is accomplished

On days when the sun shone there was a marked difference between the charts. On the north side, which received very little sunshine, the temperature never rose above 83 F and the relative humidity never went below 44 per cent, while on the south side the temperature in the sun was above 100 F for from 2 to 5 hr, and the relative humidity was below 35 per cent for 2 to 6 hr on each of 5 days. On the east and west sides of the building the conditions were intermediate between the north and south sides.

It is not expected that the air to a fan of 10,000 or 20,000 cfm capacity would be affected by any such amount as shown by the figures above. It is reasonable to expect, however, that there would be an appreciable difference in the temperature and humidity, favoring the southern exposure, for on that side the ground, the side of the barn, and other materials receive the direct rays of the sun and transfer some of this heat to the air which passes over them.

For the ordinary installation there would be an area of several hundred square feet around the fan inlet that would affect the air temperature. For a fan capacity of 15,000 cfm an increase in air temperature of 1 F would increase the moisture absorbing capacity 16 lb of water per hour.

When each square foot of area exposed to the sun's rays absorbs so much heat, it would appear wise to take advantage of this heat in the mow-curing system.

Respiration losses. Another source of heat for hay drying is the respiration process. If the moisture content is not reduced rather rapidly these chemical and (or) bacteriological processes take place, resulting in a loss of dry matter. In case a blower or fan is being used the equilibrium temperature is quite low even though a considerable amount of heat is generated.

In order to evaluate the quantity of heat available from this source, it is assumed that the heating value of the dry matter is 6750 Btu per lb and that the processes by which it is consumed liberate 5000 Btu per lb, or about 75 per cent of the available heat.

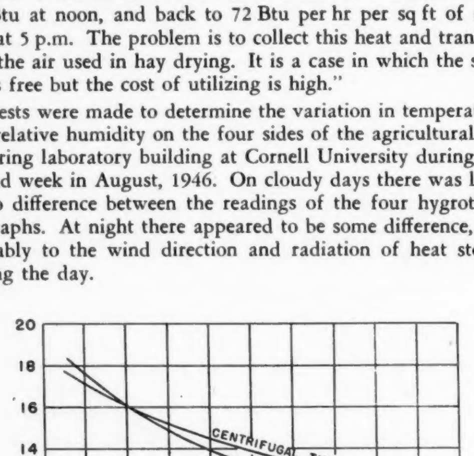


Fig. 4 Reduction of fan or blower discharge as depth of hay on a mow-curing system increases

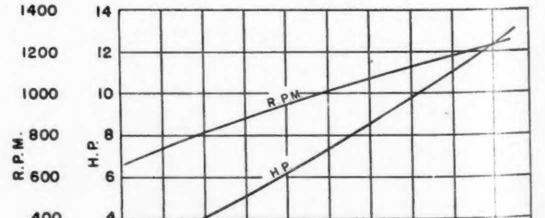
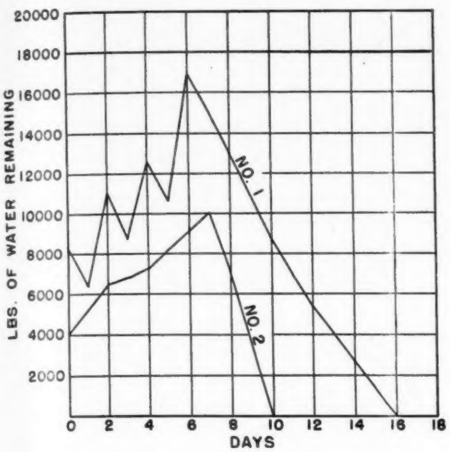


Fig. 5 Increase in blower speed and input power required to maintain constant blower discharge as depth of hay increases



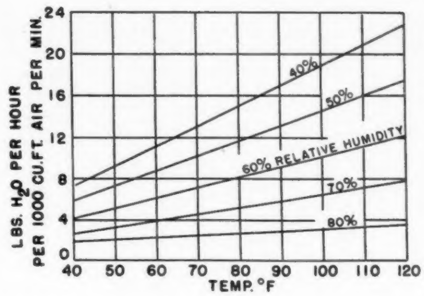


Fig. 6 *(Left)* Graphical comparison of two hypothetical mow-curing systems: No. 1 Constant speed fan, no heat. No. 2 Constant blower discharge, with engine heat • Fig. 7 *(Right)* Curves for obtaining the capacity of air for moisture under different atmospheric conditions. (Assume relative humidity will be increased to 90 per cent)

It should be kept in mind that this heat is by no means free. If the hay (with 15 per cent moisture) is worth $12 per ton, it makes rather expensive fuel. Coal has a heating value about twice as great as that of the hay, and either coal or oil would be less expensive in most instances, except for the extra equipment involved in its use.

The gasoline engine as a source of power. A number of installations have used gasoline engines as a source of power. The cost of installation, maintenance, and the repair of such equipment is high. However, there are several advantages that offset the increased expense as follows:

1 Gasoline engines are not subject to damage from overload when driving fans or blowers.

2 Speed of the fan or blower may be varied quickly and easily, thus making it possible to change the quantity and pressure of the air as desired.

3 The heat given off by the cooling system of the engine and the heat from its exhaust may be entrained in the air, thus increasing the amount of moisture that will be evaporated.

Assume that a 7½-hp engine is required to furnish 24,000 cfm for a mow-curing system. A gasoline engine supplying this power would give off heat at the rate of approximately 85,500 Btu per hr.

At 70 per cent efficiency this amount of heat would evaporate 57 lb of water per hr.

Air at 70 F and 65 per cent relative humidity will remove 6 lb of water per hr per 1000 cfm, and 24,000 cfm will remove 144 lb of water per hr. Thus there would be 57/144 = 0.39, or 39 per cent increase in evaporation rate due to heat from the engine.

There are probably many instances where this extra heat would pay for the extra expense and trouble of the gasoline engine.

C. E. Frudden in his paper, entitled "Factors Controlling Rate of Moisture Removal in Barn Curing Systems", in AGRICULTURAL ENGINEERING for March, 1946, includes curves showing estimated decrease in the amount of air leaving the top of the mow as the depth of hay is increased. He also gives curves that show the variation in discharge pressure with increased depth.

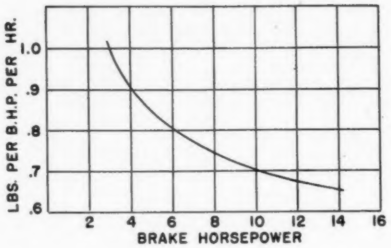
If a fan or blower is run at constant speed, the actual discharge decreases as the pressure increases. Using curves developed by blower and fan manufacturers and curves of resistance to air flow through the mow similar to those in Mr. Frudden's report, one finds that the fan or blower discharge decreases as shown in the curves of Fig. 4.

If as mentioned in the discussion above one uses a gasoline engine to drive the blower, he may vary the speed and thus maintain constant discharge over a wide range of operating conditions. Again one may use blower characteristic curves and curves of flow through the mow to calculate the variation in speed and power required to give constant discharge (cfm per sq ft) as shown in Fig. 5.

In actual use of a gasoline engine probably neither constant speed nor constant quantity would give most economical operation. But there is an advantage in being able to increase or decrease the blower discharge at will. When conditions for field curing are good, the blower may be operated at reduced speed to provide only a small amount of final evaporation. Under adverse weather conditions the blower may be speeded up to the capacity of the engine. This would result in in-

TABLE 1. EXAMPLE NO. 1

Day	Weight of hay added, lb	Per cent moisture	Pounds to be removed	Feet added	Depth, foot	Temperature, F	Relative humidity	Pounds water per hr per 1000 cfm	Cfm	Efficiency factor	Pounds of water evaporated: By air	By respiration	Total	Pounds of water remaining (above 15 per cent)
0	28330	40	8330	4.7	4.7									8330
1						77	70	5	16000	0.83	1590	100	1690	6640
2	26160	35	6160	4.7	9.4	77	70	5	16000	0.83	1590	200	1790	11010
3						79	60	8	13300	0.71	1810	400	2710	8800
4	26160	35	6160	4.7	14.1	79	60	8	13300	0.71	1810	600	2410	12550
5						78	65	6.5	11800	0.62	1140	800	1940	10610
6	28330	40	8330	4.7	18.8	78	65	6.5	11800	0.62	1140	900	2040	16900
7						80	63	7.2	10600	0.52	950	1000	1950	14950
8						80	63	7.2	10600	0.52	950	1000	1950	13000
9						80	58	8.8	10600	0.52	1160	1000	2160	10800
10						80	58	8.8	10600	0.52	1160	1000	2160	8680
11						78	65	6.5	10600	0.52	860	900	1760	6920
12						78	65	6.5	10600	0.52	860	700	1560	5360
13						80	63	7.2	10600	0.52	950	400	1350	4010
14						80	63	7.2	10600	0.52	950	300	1250	2760
15						82	58	9.0	10600	0.52	1190	200	1390	1370
16						82	58	9.0	10600	0.52	1190	100	1290	80



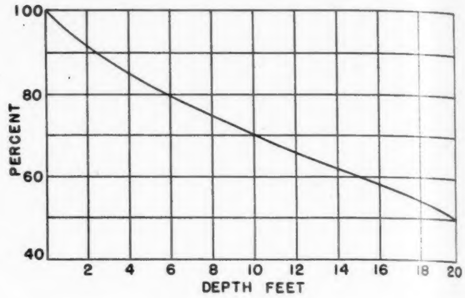


Fig. 8 *(Right)* Specific fuel consumption curve for a gasoline engine operating a fan or blower for a mow-curing system • Fig. 9 *(Extreme right)* Approximate variation in per cent of air leaving the top of the mow as the depth of the hay is increased

creased air flow and increased supplementary heat, both of which accelerate drying.

By varying the blower speed in this manner the farmer may meet the needs of the season and at the same time use a minimum of power and heat.

Two examples are given here to illustrate the effect of the various factors on rate of curing. If the moisture content of the hay is not reduced to something under 20 per cent in the time indicated by Fig. 1, the quality of the hay is likely to be inferior.

Example No. 1: (See Table 1). Mow floor area = 1000 sq ft; propeller-type fan with constant-speed (electric-motor) drive. Design is such that the fan delivers 16 cfm per sq ft at ¾ in of water static pressure. All design features are in accordance with generally accepted good practice. The fan intake is on the north side of the barn.

Hay is loaded on the system every other day, each batch adding something over 4 ft depth (10 tons of hay with 15 per cent moisture). The first and last batches have 40 per cent initial moisture and the other two 35 per cent. The total weight of dried product is 40 tons.

The fan is started immediately after the first loading and is run continuously until all hay is dry.

Respiration loss is assumed to start immediately, reach maximum rate after 7 days, and then decrease as the hay becomes dry.

Example No. 2: (See Table 2). Mow floor area = 1000 sq ft; centrifugal-type blower driven by a gasoline engine. Speed is controlled to give 16 cfm per sq ft under all conditions. All design features are in accordance with generally accepted good practice. The fan intake is on the south side of the barn. Heat from the engine exhaust and cooling system is used.

Slightly more than two feet (5 tons, 15 per cent product) are put on the system every day until the same total quantity as in Example No. 1 is in the mow. All hay has an initial moisture content of 40 per cent.

The blower is started immediately after the first loading and is run continuously until all hay is dry.

It is assumed that the use of engine heat accelerates the drying enough to prevent respiration losses.

For calculating the capacity of the air for moisture two-day averages of temperature and humidity were taken, and pounds of water per hour per 1000 cfm were obtained from Fig. 7.

Fan discharge quantities for Example No. 1 were taken from Fig. 4.

Engine speed and horsepower for Example No. 2 were taken from Fig. 5; fuel consumption from Fig. 8.

Efficiency factors were taken from Fig. 9.

Hay density was assumed to be 470 cu ft per ton (at 15 per cent moisture).

Figs. 4, 7, and 9 are based partly or wholly on information from C. E. Frudden's report.

Fig. 6 compares the performance of the two systems. It will be seen that, in Example No. 1, 10 days are required to bring the moisture content down to 15 per cent after the last hay is placed in the mow. In Example No. 2, the hay reaches the desired dryness in about 3 days after the hay is all in the mow. The main factors that cause this difference are as follows:

1 By loading the system more frequently with smaller amounts of hay, the resistance to air flow is kept to a minimum at all times.

2 Air taken from the side of the barn which receives the most sunshine contains "free heat". Even though the temperature difference is slight, this difference is important since it is heat that evaporates the moisture. It is not unreasonable to expect a 5 to 10 per cent increase in capacity due to this factor.

3 Maintaining high blower discharge as the mow is filled helps keep up the capacity of the system when such capacity is needed most.

4 Use of heat from the exhaust of a gasoline engine appears to be a very practical idea. The tabulated figures for Example No. 2 show that heat from this source may well be a substantial percentage of the total.

TABLE 2. EXAMPLE NO. 2

Day	Weight of hay added	Pounds to be removed	Depth, ft	Pounds of water per hour per 1000 cfm	Pounds per hour	Blower rpm	bhp	S.F.C.	Heat recovery	Pounds per hour from engine heat	Total pounds per hour	Efficiency factor	Pounds evaporated (24 hr)	Pounds of water remaining (in excess of 15 per cent)
0	14170	4170	2.4											4170
1	14170	4170	4.7	5.6	89.7	750	3.2	1.0	0.88	51.5	141.2	0.90	3050	5290
2	14170	4170	7.0	5.6	89.7	830	4.3	0.88	0.85	58.5	148.2	0.83	2960	6500
3	14170	4170	9.4	8.7	139	910	5.6	0.82	0.84	70.5	209.5	0.77	3870	6800
4	14170	4170	11.8	8.7	139	990	7.0	0.77	0.83	82	221	0.71	3760	7210
5	14170	4170	14.1	7.1	114	1060	8.4	0.74	0.82	85	199	0.66	3150	8230
6	14170	4170	16.5	7.1	114	1125	9.8	0.71	0.81	103	217	0.62	3230	9170
7	14170	4170	18.8	7.9	127	1190	11.3	0.68	0.80	112	239	0.57	3270	10070
8				7.9	127	1250	12.8	0.66	0.79	122	249	0.52	3110	6960
9				9.9	158	1250	12.8	0.66	0.79	122	280	0.52	3500	3460
10				9.9	158	1250	12.8	0.66	0.79	122	280	0.52	3500	

All hay has 40 per cent initial moisture.
Fan discharge is maintained at 16000 cfm.

Air temperature is 1F higher than for Example No. 1.

Soil Erosion Studies — Part I.

By W. D. Ellison
MEMBER A.S.A.E.

SUBJECTS for research are obviously those which demand solutions of problems we do not fully understand. And in all matters not fully understood, our individual concepts may vary greatly. The approach that we make in our studies will depend upon our concepts of the problems we would solve. These concepts are expressed in our definitions. Because the type of approach we make depends upon these definitions, the research worker will often spend long hours developing them. Sometimes change in a definition will institute a change in the research worker's approach. The definition on which this approach to soil erosion problems is based is: "Soil erosion is a process of detachment and transportation of soil materials by erosive agents[1]."

This definition describes the erosion process as consisting of two principal, sequential events. In the first event soil particles are torn loose (detached) from their moorings in the soil mass and made available for transport. In the second event, detached soil materials are transported. We cannot combine these two processes and express them as a single quantitative result, because they cannot be expressed in like units. The detachment process is expressed in terms of weight or volume per unit area, such as tons per acre. The transportation process, on the other hand, must be expressed in terms of weight or volume moved through distance, such as ton-miles per acre.

Not only is it necessary to treat soil detachment and transportation as independent variables in expressing the final results, but it is also necessary to carry this same breakdown into the detailed studies. For example, the erosive capacity of an agent is comprised of the two independent variables of (a) detaching capacity and (b) transporting capacity, and these must be studied separately. The same reasoning applies to the soils. When we study a soil's erodibility, we must approach the problem by studying its detachability and its transportability. Each of these factors may vary independently of the other. Some examples to illustrate these points will be cited.

Detaching and Transporting Capacities of Erosive Agent. This first example is to illustrate how and why the *detaching capacity* and the *transporting capacity* of an erosive agent may vary each independently of the other. For this purpose let us consider some exploratory experiments the author once made on a soil bed consisting of a well-compacted clay. When surface flow containing only clear water was applied on the upper end of this clay bed, the clear water flow did not have sufficient detaching capacity to cause much erosion on the well-consolidated clay, and the runoff was almost clear as it flowed off the lower end.

When soil containing some highly abrasive fractions was injected into this flow at the point where it flowed onto the clay bed, this increased the detaching capacity of the flowing surface water and greatly accelerated the erosion. To increase the amounts of soil injected into the flow will also cause an increase in the detaching capacity of the flow, and at the same time it will decrease the transporting capacity. The amounts of soil added can be increased until approximately all of the transporting capacity of the flow will be absorbed in transporting the injected soil, and there will then be very little erosion on the clay bed because of a lack of transporting capacity.

Now to review: When only clear water was applied, there was maximum transporting capacity and minimum detaching capacity, and very little erosion. On the other hand, when the water applied was fully charged with soil, there was maximum detaching capacity and minimum transporting capacity, and again there was very little erosion. The maximum erosion will occur when the detaching and transporting capacities of the flow are balanced, that is, when the flow contains just enough abrasive materials to detach as much soil as the flow will carry. This condition of balance will change with each change in the soil's erodible characteristics. Therefore, a condition of flow which is found to be most erosive on one soil may not be most erosive on another soil.

Detachability and Transportability of Soils. A second example will illustrate the need for separating the factors of detachability and transportability of the soil when we study soil erodibility. Let us illustrate this with Table 1. In the left-hand column the soils are listed in the order of their detachability, with those most detachable at the top of the column. In the right-hand column the same soils are listed in the order of their transportability, with those of highest transportability appearing at the top of the column.

TABLE 1.

Detachability	Transportability
Fine sand	Clay
Loam	Loam
Clay	Fine sand

Clays in general have low detachability and high transportability. The reverse is generally true of sands. We would therefore say that most sands and clays are of low erodibility —but for entirely different reasons. The clay is of low erodibility because it is difficult to detach. The sand is of low erodibility because it is difficult to transport. Control of the detachment and transportation processes will often require different types of erosion control practices. Therefore, we cannot apply control practices most effectively until we have studied the detachment and transportation separately; and we must know whether the soil's detachability or its transportability tends to limit the soil erosion process.

Soil erosion occurs when an erosive agent is applied to an erodible soil. We can check the erosion process by using what we commonly refer to as erosion-control practices. Each of these practices will tend to reduce either the soil detachment or the soil transportation, or both. To evaluate an erosion-control practice fully we must evaluate its effects on the detachment and transportation processes separately.

Raindrops and Surface Flow as Separate Erosive Agents. As we have indicated above, it has been found necessary to treat falling raindrops and flowing surface water as separate erosive agents. The energy of the falling raindrops is applied vertically downward at velocities ranging up to more than 30 feet per second. The surface flow, on the other hand, is applied horizontally, usually at velocities of not more than a few feet per second; and on the smooth surfaces of the land, outside the rills and gullies, velocities of surface flow are usually

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[1]Soil Detachment and Transportation, "Soil Conservation," February, 1946, vol. 11, no. 8, p. 179.

less than ¼ foot per second. These great differences in velocities and direction of application of their energies suggest that the impact of falling raindrops and the scouring action of surface flow will produce widely different results on the soil. And they do.

Because of the floating action of the surface water, and because it acts parallel to the surface of the soil, it should be expected that this agent will be very effective in transporting soils downslope. The falling raindrops, on the other hand, which are usually applied almost perpendicularly to the surface of the land, should be expected to have maximum effect on soil detachment and to have little direct effect on soil transportation. There will be an exception to this, of course, where the land is sloping and where the raindrops are driven in at an angle so that they do not strike perpendicularly to the surface but tend to splash most of the soil in a single direction. Experimental results have shown that on a 10 per cent slope, where the raindrops fall without wind, three-fourths of the soil splashes move in downhill directions, while about one-fourth move in uphill directions[2]. This action causes raindrop splashes to transport soil off a field. It will cause them to beat down a hilltop by splashing most of the soil toward the valley bottoms, just as they beat down large sand piles by bouncing most of the sand in down-slope directions.

Detachment and Transportation Hazards. After we have evaluated all the factors that affect soil detachment, we must be able to sum these up and determine the probable net results of all these factors working together. This net result may be referred to as the *soil detachment hazard.* When a soil is highly detachable and one or more of the erosive agents has a high detaching capacity, there is a large soil detachment hazard. This hazard may be effectively reduced with the proper soil erosion control practices.

HIGH SOIL TRANSPORTATION HAZARD

This same line of reasoning applies to the transportation hazard. We must be able to sum up all the factors that affect soil transportation, and determine their net results. If the soil is highly transportable, and one or more of the erosive agents possesses high transporting capacity, there is a high soil transportation hazard. This hazard too may be effectively reduced through proper use of soil erosion control practices.

In order to design the most effective soil erosion control practices, using these methods, we must be able to evaluate the end results of all of the factors affecting each of the soil erosion hazards. For example, to check soil detachment effectively we must be able to determine the resultant of all of the factors affecting the detachment process and bring them into near equilibrium with erosion control practices, so that the rate of soil detachment will approach zero. The same must be done with the factors that affect soil transportation.

The resultant of the principal factors which affect soil detachment and its transportation may be summed up for any point on a field. Several types of units could be used in such an expression. One way of doing this will be shown for the detachment process. It is based on determining how many units of soil will be detached by one unit of detaching capacity, and then determining the total units of detaching capacity of the erosive agent. These are then summed up and the magnitude of the detachment hazard is shown by this formula:

SOIL DETACHED = (SOIL'S DETACHABILITY) × (AGENT'S DETACHING CAPACITY)

(This is the detachment hazard)	Units of soil detached by one unit of the erosive agent's detaching capacity	Total units of detaching capacity of the erosive agent

This equation includes only the soil and the erosive agent. If we introduce an erosion control practice which will reduce the soil detachment, this will serve as a resistance to reduce the detachment process, and so we may divide the right-hand side of the above equation by a resistance value, *R*. As the effectiveness of a control practice is increased, the value of *R* is increased, and the detachment hazard is made to approach zero. To make practical use of this equation, we must evaluate (1) the soil's detachability, (2) the agent's detaching capacity, and (3) the resistance to detachment of each erosion control practice.

This same type of equation can be applied to the transportation process. The transportation hazard will be a function of the transportability of the soil materials and the transporting capacity of the erosive agent. And here, too, we introduce a resistance factor *R* to impede the transporting agent and reduce the transportation hazard.

Problems in Application. In practical farm work it is never possible to keep all of the factors which affect these hazards in such a state of balance as will eliminate all soil erosion the year round. We invariably find it necessary to permit a certain amount of soil detachment and transportation almost the year round. This is especially true with crops that do not have closed canopies. Again during times of seedbed preparation and planting there are usually some erosional hazards associated with most of our crops. The amount of action that we can tolerate in either of these hazardous processes will vary. It will vary with the soil type and with other conditions. In most sandy soils, for example, we shall want to keep detachment at a very low level because when sandy soils are detached and set in motion, they may lose most of their organic matter and nutrient materials.

DETACHMENT AND TRANSPORTATION HAZARDS

There are many things to be considered in deciding on how large a hazard we can tolerate in each of the detachment and transportation processes. For example, when soil is detached in the erosion process, the surface water is made muddy and this mud interferes with infiltration. Therefore, when infiltration is inadequate, we make a special effort to maintain a very low detachment hazard. Another important consideration when deciding on how large a detachment or transportation hazard can be tolerated is the matter of their interrelationships. If we find a high transportation hazard at some point on a field, one which cannot be effectively reduced, we must then reduce the detachment hazard, remembering that if soil is not detached it cannot be transported. That is what we do when we keep steep hillsides in permanent grass; and when we apply mulch to steep cuts and other steep areas where the transportation hazard is high, we reduce the detachment hazard. On more level areas the transportation hazard is smaller and a higher detachment hazard can be tolerated, for we know that much of the detached soil will not be carried off the field.

On some fields there may be a very high detachment hazard which cannot be effectively reduced while growing cultivated crops. In these areas we find bench terraces tending to develop on each contour line where a ridge or buffer strip checks the downslope movement of water. Here the transportation hazard must be maintained at a very low level.

It is necessary to treat the impact of falling raindrops and the flowing surface water as separate erosive agents and to evaluate them separately when determining the detachment and transportation hazards. Some work was reported on methods of doing this in previous papers[2,3]. Additional methods have since been developed and some of these will be discussed in papers to follow in later issues.

[2]Studies of Raindrop Erosion, AGRICULTURAL ENGINEERING, April and May, 1944, vol. 25, no. 4, pp. 131-136, and no. 5, pp. 181-182.

[3]Two Devices for Measuring Soil Erosion, AGRICULTURAL ENGINEERING, February, 1944.

Some Permeability Characteristics of Saline and Alkali Soils

By J. E. Christiansen
MEMBER A.S.A.E.

ONE of the soil characteristics of special importance in connection with drainage and reclamation of saline and alkali soils is capacity to transmit water. Reclamation necessitates leaching to remove excess salts, and often to bring about an exchange of calcium for sodium. The success of drainage and leaching operations is dependent upon the permeability of the soil and subsoil materials.

Permeability is the rate at which a fluid will move through a porous medium under standard conditions. The simplest expression for defining permeability is the "Darcy" equation [11]* which may be written:

$$Q = \frac{PAH}{L} \qquad [1]$$

or

$$q = P\frac{dh}{dl} \qquad [2]$$

where Q is the flow (volume per unit time), P is the Darcy permeability coefficient, A is the cross-sectional area of the soil column, H is the difference in hydraulic head between the two ends of the column, and L is the length of the column. In equation [2], q is the flow per unit area, and dh/dl is the hydraulic gradient. In these equations, P is a proportionality factor which has the dimensions of velocity, i.e., LT^{-1}. Hereafter, P will be referred to as the "permeability". It is proportional to the acceleration of gravity and the density of the fluid, and inversely proportional to the viscosity. For non-colloidal materials, it is a function of the square of the average linear dimension of the capillary pores through which the flow occurs. This can be expressed mathematically by the equation:

$$P = f\left(\frac{D^2 g \rho}{\mu}\right) \qquad [3]$$

where f indicates "function of", D is the average pore dimension, g is the acceleration of gravity, ρ is the density of the fluid, and μ is the viscosity of the fluid. Although various combinations of these factors have been used as the permeability unit, P seems to be the most readily visualized and easiest to apply to practical problems. Since P is a function of viscosity which is dependent upon temperature, it is necessary to correct to a standard temperature before comparisons can be made. Permeability corrections for temperature are approximately 1.5 per cent per degree Fahrenheit, or 2.5 per cent per degree Centigrade.

Permeability tests on soils have been made at the U. S. Regional Salinity Laboratory in connection with research dealing with irrigation and drainage problems, and with water spreading for storage underground. The methods and techniques used have varied with the specific problem. For example, for most irrigation problems, where it is a question of infiltration of 6 to 12 in of water into, and possibly through, the surface soil, a technique has been developed by Fireman[5] utilizing inexpensive equipment that can be readily constructed at any laboratory. In connection with studies on water spreading where long-time tests are desired, the author has used glass percolation tubes[2] of smaller cross-sectional area as permeameters which require less reservoir capacity and facilitate tests on highly permeable soils. Also in connection with this study, tests have been conducted on undisturbed soil cores 4½ and 5 in in diameter, and from 16 to 36 in in length[8]. These cores were provided with manometers so that the permeability of the soil at different depths could be determined.

Description of Methods. For the studies reported in this paper, glass tube permeameters were used. The details of this method have been described elsewhere[2,3] so that they will be only briefly discussed here. The general arrangement is shown in Fig. 1, except that only 50 or 100 g of soil were used for some of the tests. The soil is placed on a short column of quartz sand which in turn is supported on a fibrous glass or brass screen. The water level is maintained constant with a Mariotte siphon from a 5-gal supply bottle. Usually two or more permeameters are supplied from one bottle. For soils of low permeability, the simple expedient of inverting a 500-ml supply bottle over the top of the permeameter is sometimes used.

The soils are air-dried, sieved through a 2-mm screen and poured into the permeameter through a 14-mm (I.D.) glass tube which is rotated with a planetary motion to distribute the soil evenly as it is raised. The soil is settled to a fairly uniform density by dropping the tube on its point on a wooden block ten times through a height of 2.5 cm. The length of the soil column is carefully measured, and this dry length of column is used in the permeability calculations. To avoid disturbing the soil during wetting, a small cork disk is dropped on the surface to cushion the effect of the falling water. The time for the soil to wet through and for dripping to commence is noted. The water passing through the column is collected in graduate cylinders of appropriate size. Except for soils of unusually

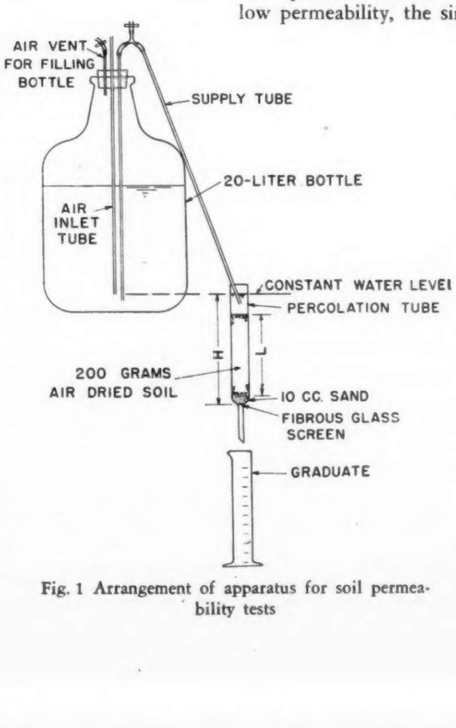
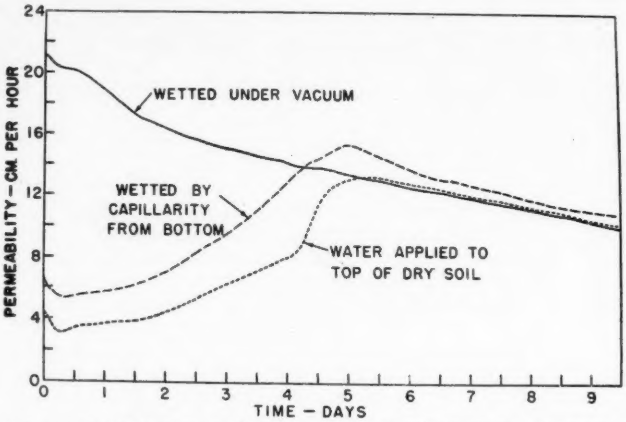


Fig. 1 Arrangement of apparatus for soil permeability tests

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers, at Sacramento, Calif., February, 1946, and is a contribution from the U. S. Regional Salinity Laboratory at Riverside, Calif., Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture, in cooperation with the eleven Western States and the Territory of Hawaii.

J. E. CHRISTIANSEN was formerly irrigation and drainage engineer, U. S. Regional Salinity Laboratory, and is now dean, school of engineering, industries, and trades, Utah State Agricultural College.

*Superscript numbers refer to appended references.



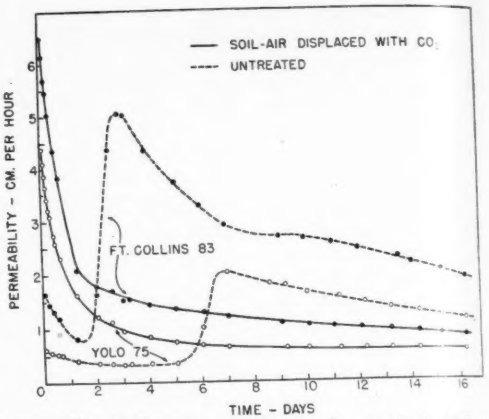
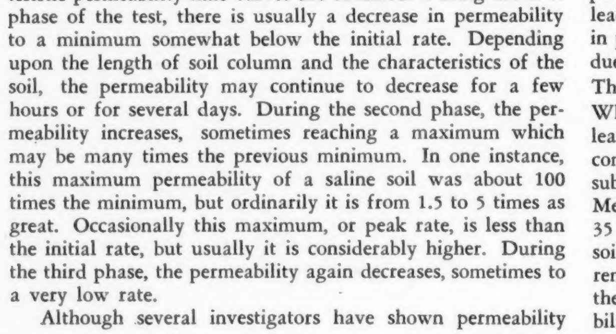


Fig. 2 *(Left)* The effect of different methods of wetting on air entrapment and permeability of Hesperia sandy loam • Fig. 3 *(Right)* Effect of displacing the soil-air with CO_2 before wetting on the permeability of two soils

low permeability, the initial permeability is determined from the time required for the collection of about 50 ml of water. For some tests, depending upon the detail required, all the water passing through the soil column is collected and measured at daily intervals after the initial changes in permeability have taken place. When rates are so high that it is not convenient to collect and measure all of the water, short-time tests of one-half or one hour's duration are made daily. For convenience in comparing different soils, waters, or treatments, the calculated permeability, *P*, is usually plotted against time.

General Characteristics of Soil Permeability. When long-time permeability tests are made on agricultural soils, characteristic permeability-time curves are obtained. During the first phase of the test, there is usually a decrease in permeability to a minimum somewhat below the initial rate. Depending upon the length of soil column and the characteristics of the soil, the permeability may continue to decrease for a few hours or for several days. During the second phase, the permeability increases, sometimes reaching a maximum which may be many times the previous minimum. In one instance, this maximum permeability of a saline soil was about 100 times the minimum, but ordinarily it is from 1.5 to 5 times as great. Occasionally this maximum, or peak rate, is less than the initial rate, but usually it is considerably higher. During the third phase, the permeability again decreases, sometimes to a very low rate.

Although several investigators have shown permeability curves of this type, there appeared to be no satisfactory explanation in the literature as to why the permeability first decreased, then increased, and again decreased. Field tests (according to unpublished data from H. L. Haehl, North Kern Water Storage District, Bakersfield, Calif.), in connection with water-spreading investigations, showed these same typical permeability curves. As a result of research at this Laboratory, an explanation can now be given for this behavior. During the first phase, most saline soils tend to swell and disperse to some extent, as salts are removed and this results in a reduction in the effective size of the pores. This initial reduction in permeability can often be decreased, or completely eliminated, by increasing the calcium content of the leaching solution with $CaCl_2$ or gypsum, $CaSO_4$. The increase in permeability during the second phase has been found to be due to the gradual elimination of air entrapped in the soil. The air disappears as it is dissolved by the percolating water[2]. When tap water, which may be supersaturated with air as it leaves the faucet, is allowed to stand for a few hours and come to approximate equilibrium with the atmosphere, it will subsequently slowly dissolve the air entrapped in the soil. Measurements on one soil studied indicated that from 15 to 35 per cent of the pore space was occupied with air when the soil was wetted. This air is completely immobilized and is removed only in solution. The air bubbles appear to occupy the larger pores and are very effective in reducing the permeability. The effect of different methods of wetting the soil is indicated in Fig. 2. Later tests[3] indicated that complete saturation could be obtained quickly by displacing the air in the soil with CO_2 before wetting. This usually



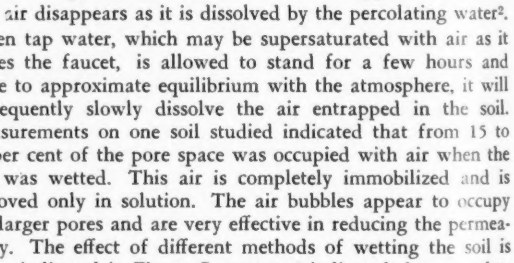
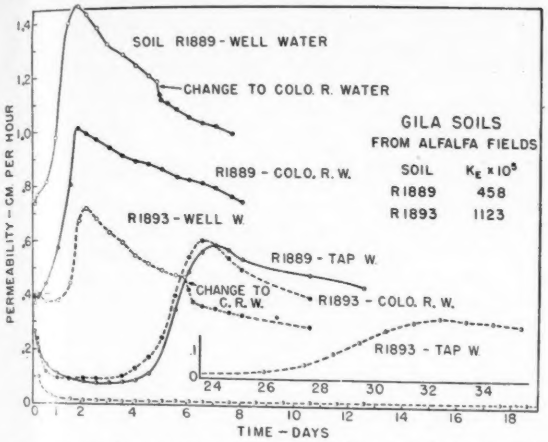


Fig. 4 *(Left)* Permeability-time curves from three sections of a soil column. Note that the air is displaced from top section first, which reached its maximum permeability early in the second day, and that the third section did not reach its maximum permeability until the third day. Although the rate of sealing was approximately constant for all sections, the actual permeabilities differed somewhat • Fig 5 *(Right)* The relative effect of distilled water, tap water, and additions of mercuric chloride and calcium chloride on the permeability of a soil



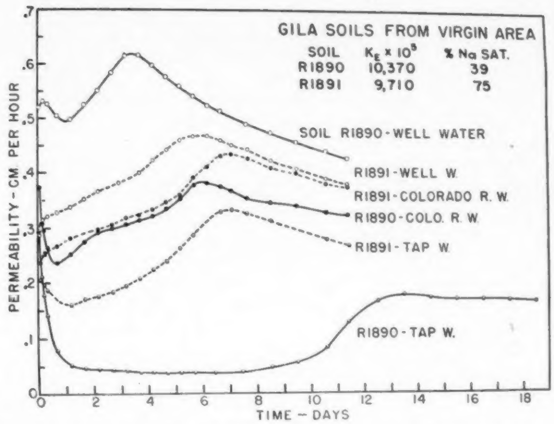


Fig. 6 *(Left)* Permeability-time curves for Gila soils of low to medium salinity with three waters of different salt content. (Curves are for 1 tube of each treatment) • Fig. 7 *(Right)* Permeability-time curves for highly saline Gila soils with three waters of different salt content. (Curves are for one tube of each treatment)

results in a rapid decrease in permeability of the soil during the first few days of the test, apparently due to instability of the pores. Typical permeability curves for two soils showing the effect of air displacement with CO_2 are shown in Fig. 3.

The decrease in permeability during the third phase is due primarily to a sealing effect resulting from microbial activity. This decrease is undoubtedly going on from the beginning but becomes noticeable only after the air is eliminated from the system. Soils vary appreciably in their rate of sealing. Surface soils which contain more organic matter generally show more rapid sealing than subsoils. Undisturbed cores that have been studied show that the sealing is most pronounced in the surface soil and diminishes with depth, with relatively little sealing below 2 ft. When disturbed soils are studied, the sealing takes place uniformly throughout the column, as evidenced by Fig. 4. For these tests a permeameter with side manometers was used so that the permeability of each section of column could be determined independently. Recent work by Allison[1] confirms earlier tests with various disinfectants which indicated that microbial activity is primarily responsible for the decrease in permeability which occurs under prolonged leaching. The relative effects of distilled water, tap water, and additions of mercuric chloride, $HgCl_2$, and calcium chloride, $CaCl_2$, to the leaching solution are shown in Fig. 5. Although the addition of $CaCl_2$ increased the permeability, it apparently had no effect on the rate of sealing, whereas 20 ppm of $HgCl_2$ practically eliminated the sealing.

Some Characteristics of Saline and Alkali Soils. Saline soils are those which contain a sufficient concentration of soluble salts to affect plant growth adversely. Soils having more than 0.2 per cent salts are generally considered saline. The salts present in soils are principally the chlorides and sulfates of calcium, magnesium, and sodium. Occasionally appreciable concentrations of potassium salts or nitrates are found. Alkali soils have been distinguished from saline soils in that they are more alkaline, having a pH in excess of 8.5[10] due to the presence of sodium carbonate, or a relatively high percentage of exchangeable sodium. Alkali soils do not always contain appreciable amounts of soluble salts. They are generally dispersed and usually have low permeabilities. It is difficult to draw a sharp line between alkali and saline soils, and no attempt to do so is intended in the above description. Gardner[7] has recently discussed the physical and chemical properties of sodium soils and has presented some permeability data on several soils showing the effect of additions of gypsum.

The permeability characteristics of some saline and alkali soils have been determined for various specific purposes in recent experiments. A few of these will be used as examples to illustrate some of the permeability characteristics.

Gila Soils from Arizona. Recently soil samples were secured from an area along the lower Gila River in Arizona which is now irrigated with well water having salt concentrations ranging from about 2000 to more than 10000 parts per million. This area may be supplied with water from the Colorado River, and the question was raised as to whether the change to the lower salt water would cause difficulty in securing water penetration. Fireman and Magistad[6] have pointed out that the "permeability decreases greatly when the salt-concentration is reduced following percolation with high-sodium water." To obtain information on this point, some permeability tests were made on these samples, using synthetic well water of about 5000 ppm of salt, synthetic Colorado River water with about 800 ppm, and Riverside tap water which has about 280 ppm. The five soil samples were from the 0 to 12 in depth in two alfalfa fields and three virgin areas. They were all of similar texture and classified as Gila fine sandy loam, or very fine sandy loam. Their salinity characteristics are given in Table 1.

Two of the samples were very saline, and three were only slightly to moderately saline. Four of them contained sufficient exchangeable Na to be considered sodium soils, but none of them had a high pH, even on dilution. The analyses indicate that the soluble salt was predominately NaCl with the exception of R1892, where Ca and NO_3 ions predominated. The permeability of these soils is given in Table 2 and illustrated in Figs. 6 and 7.

The reason why soil R1891 (Fig. 7) did not seal as much as R1890 (Fig. 7) or R1893 (Fig. 6) when leached with tap water, in spite of the fact that it had more exchangeable Na, is due to differences in gypsum content. Analyses indicated that both R1890 and R1891 contained some gypsum, whereas R1893 did not, and that R1891 had the largest amount. When sufficient gypsum is present to replace the exchangeable Na with Ca upon leaching, little or no sealing takes place during the first phase of the test.

TABLE 1. CHARACTERISTICS OF GILA SOILS*

Soil	Field	$K_e \times 10^5$ at 25C†	Total salt, % (approx.)	Exch. Na percentage
R1889	alfalfa	458	0.19	22.5
R1890	virgin	10373	6.5	39.0
R1891	virgin	9709	7.2	74.9
R1892	virgin	706	0.25	1.4
R1893	alfalfa	1123	0.45	17.2

*Analyses by Rubidoux Laboratory, U. S. Department of Agriculture, Riverside, Calif.

†K_e is the conductivity of the saturation extract in reciprocal ohms.

TABLE 2. PERMEABILITY OF GILA SOILS WITH DIFFERENT WATERS*

Permeability, cm/hr at 75 F

Soil	Initial	First minimum	Maximum	Five days after maximum
With Synthetic Well Water				
R1889	0.72	0.72	1.47	------
R1890	0.51	0.50	0.62	0.46
R1891	0.29	0.29	0.49	0.42
R1892	1.47	1.37	1.46	1.12
R1893	0.39	0.34	0.69	------
With Colorado River Water				
R1889	0.43	0.41	1.08	0.85
R1890	0.37	0.24	0.39	0.33
R1891	0.24	0.24	0.47	0.37
R1892	1.37	1.31	1.40	1.12
R1893	0.24	0.09	0.57	0.34
With Riverside Tap Water				
R1889	0.27	0.08	0.61	0.48
R1890	0.30	0.043	0.19	0.17
R1891	0.20	0.17	0.32	0.25
R1892	1.14	1.06	1.25	1.02
R1893	0.10	0.011	0.19	0.15

*Mean values for triplicate tubes.

Soils R1889 and R1893 were dried and resieved, and the permeabilities again determined with both Colorado River water and tap water. On this second run the permeabilities were appreciably higher, and essentially the same regardless of the water used in the initial tests. The permeabilities were consistently higher, by from 10 to 50 per cent, for the Colorado River water than for tap water. Base exchange analyses, after the initial leaching, indicated that the exchangeable Na had been reduced to less than 6 per cent in all cases and did not vary greatly for the different waters used. Although the permeability of four of the soils was relatively low, there appeared to be little tendency for them to seal up when Colorado River water was used, although they did seal appreciably with tap water. Before conclusions can be drawn regarding the effect of the Colorado River water on these soils, field infiltration tests should be made for comparison.

The Salinity Laboratory is cooperating with the Utah Agricultural Experiment Station and local drainage districts in a drainage and leaching study of the Delta Area in Utah. This area, which is located about 150 miles southwest of Salt Lake, contains about 50,000 acres of irrigated land which receives its water supply from the Sevier River. Being on the lower end of the river system, the water is fairly saline, containing about 2,000 ppm salts, of which about 55 per cent is Na. Drainage is a limiting factor. Some of the soil is very saline and contains relatively high proportions of exchangeable Na and may, therefore, be classified alkali. Reclamation of these

TABLE 3. CHARACTERISTICS OF OASIS SOILS

Soil	Field	Depth, in	$K_e \times 10^5$ at 25C*	Total salt, % (approx.)	Exch. Na percentage	Gypsum T./A.F.
697	alfalfa	0-12	778	0.38	14.6	0.2
698	alfalfa	12-24	1340	1.4	20.0	17.8
699	abandoned	0-12	7330	5.0	45.4	6.3
700	abandoned	12-24	3810	3.5	42.6	21.8

*K_e is the conductivity of the saturation extract in reciprocal ohms.

soils will depend to a large extent upon their permeability, which is known to be very low in some cases. Israelsen and Reeve[9] found that some of the Oasis clay soil was nearly impermeable and that it was a very satisfactory material for canal lining to reduce seepage losses.

This discussion is limited to the permeability characteristics of four samples from the Delta area which represent the first and second 12-in depths taken at two locations only a short distance apart, one in an alfalfa field which is moderately saline and the other an abandoned area which is highly saline. The soils at both locations are mapped as Oasis silty clay loam. Some of the characteristics of these soils are given in Table 3.

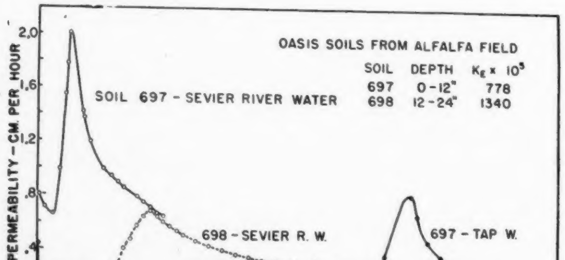
The soluble salts in the saturation extracts are predominately NaCl and Na_2SO_4. At the concentrations found in soils 698-700, gypsum is not all dissolved in the saturation extracts, but comes into solution on further dilution or leaching. Both subsoils had sufficient calcium from solution of gypsum to replace the exchangeable Na on leaching, but the surface soils did not. In the permeability tests, the soils were leached with both Riverside tap water and a synthetic Sevier River water, the results of which are given in Table 4, and illustrated in Figs. 8 and 9. *(Continued on page 153)*

TABLE 4. PERMEABILITY OF OASIS SOILS WITH DIFFERENT WATERS*

Permeability, cm/hr at 74 F

Soil	Initial	First minimum	Maximum	Five days after maximum
With Sevier River Water				
697	0.71	0.63	1.7	0.69
698	0.21	0.20	0.52	0.33
699	0.045	0.041	0.25	0.17
700	0.015-.037	0.034	0.21	------
With Riverside Tap Water				
697	0.40	0.015	0.84	0.24
698	0.16	0.09	0.30	0.22
699	0.020	0.002	0.016	0.015
700	0.013-.030	0.019	0.11	0.09

*Mean values for duplicate tubes.



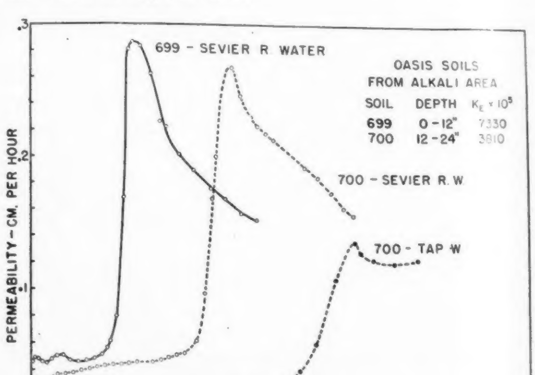


Fig. 8 *(Left)* Permeability-time curves for Oasis soils of moderate salinity with two waters of different salt content. (Curves are for one tube of each treatment) • Fig. 9 *(Right)* Permeability-time curves for highly saline Oasis soils with two waters of different salt content. Note that surface soil is affected to a greater extent by salt content of water than the subsoil which contains more gypsum. One tube with soil 699, on tap water, reached a maximum permeability of 0.021 in 97 days and the duplicate reached a maximum of 0.010 in 144 days. (Curves shown are for one tube of each treatment)

Agricultural Meteorology: An Introduction

By A. Nelson Dingle
MEMBER A.S.A.E.

PROBABLY the first question which will occur to many agricultural engineers upon seeing an article on meteorology in their professional journal, is this: How is this subject connected with my field and why should it be of sufficient interest to me to merit publication in AGRICULTURAL ENGINEERING? The answer is not simple. In fact, the author proposes to consume most of the space of this article answering that question.

Briefly, one might say that meteorology is a physical science and agricultural engineering is the application of science to the solution of agricultural problems, hence the field of agricultural meteorology is quite legitimately a form of agricultural engineering.

In general, although agricultural meteorology has long been considered by meteorologists to be an important branch of weather science, it has not had much attention from agricultural scientists. There are a number of reasons for this. Meteorology is a relatively young branch of science in point of development, and thus until very recently it has had comparatively little to offer professional agriculturists. The location of the corn and cotton belts, for example, is primarily a problem of agricultural climatology, but it was solved by practicing farmers long before the science of climatology had developed in this country.

It might be said, therefore, that farmers did pretty well by cut and try, yielding to the pressure of economic and climatic forces to establish the agriculture of the nation without any aid from weather scientists. However, there seems now to be some question as to just how well the cut-and-try system has worked out, notably in the cotton belt and the "dust bowl" regions. The problems which have arisen because of the protracted depletion of the soil in the South are of immediate concern. They should be solved correctly and quickly. The application of scientific knowledge and technique is the means of attaining the correct solutions promptly. The role of weather science is as important in these solutions as is that of soils, agronomy, or any of the other agricultural sciences, for weather is the universally limiting factor.

Not only is it important that climatology be applied to problems which have arisen from misuse of land, but also the application of both climatic science and weather forecasting techniques to current practical problems of agriculture can be of considerable economic importance. It is with these considerations in mind that the author wishes to describe briefly the state of development of the science of agricultural meteorology. With the realization that weather science has tools which can be turned to the benefit of agriculture, agricultural scientists will be in a better position to assist in the application of those tools.

The USDA Yearbook of Agriculture for 1941, "Climate and Man", constitutes a very complete and excellent report on the state of development of meteorological science with respect to agriculture at that time. Since that volume was published, with the considerable impetus of wartime research and development, appreciable advance has been made. It is common knowledge that World War II required the services of more meteorologists than had ever before been used in the field. It was necessary for these meteorologists to find solutions to problems never before encountered by weather men. The resulting program of research in all phases of meteorology was immense. For the most part, this wartime research was directed toward the solution of the problems of warmaking, but in meteorology as in other sciences the wartime developments are in large part applicable to peacetime pursuits.

Among other things the wartime research brought about an unprecedented use of statistical science in meteorology. This is of particular importance to the development of climatology and long-range forecasting, the specific branches of meteorology which are probably most directly applicable to agriculture.

Whereas the study of climate prior to the war was very slowly advancing from the generalized climatology of Köppen (1928), the requirements of war very soon made evident the necessity for a more detailed and statistically mature climatic science. Köppen's classifications of climate are based for the most part on five basic vegetative types. The classes are defined in terms of monthly means of temperature and precipitation with additional special classes for regions not adequately provided for by the basic definitions. Thornthwaite's (1931, 1933) index of precipitation effectiveness based on monthly means of temperature and precipitation represents another attempt to relate the basic meteorological elements to their vegetative products. Neither of these systems accounts for the distribution of temperature and precipitation within months.

One of the basic concepts which has been contributed by statistical science is that which points out the meaninglessness of a simple mean in the absence of the frequency distribution from which it is derived. It need not be emphasized that, for agricultural purposes, simple monthly means of precipitation and temperature are of no great value. But if the mean for a given period is supplemented by some information about the frequency of occurrence of specific ranges of temperature and/or precipitation over a given more or less homogeneous area, some useful information is immediately forthcoming. From the frequency distributions, the probability of occurrence of a specified precipitation amount and/or temperature can be computed. By the introduction of the time element, duration frequencies can be established and used in a similar way. For example, the probability of a 15-day drought occurring during the month of June over any specified region can be determined from the duration-frequency distribution of periods with negligible amounts of rain. This then is approaching the point at which a farmer's weather risk can be computed for a specific crop.

In agriculture there are always additional factors to account for. Obviously the availability of weather-risk estimates cannot answer all the questions. The effect of weather anomalies on insect pests and plant diseases, as well as that on crop yields becomes important (Hendricks and Scholl, 1943). To date surprisingly little is known about these aspects. One fact, however, is basic whether the consideration be entomological, pathological or purely agronomical: the weather is a primary variable and is probably the most important governing factor in the complex business of agriculture.

Thus the statistical ideas upon which the science must be based have been brought forth, but relatively very little has been done by way of actual development of agricultural climatology along these lines. This lag is accountable to a number of things. The bulk of data to be processed is large. The

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required frequency distributions must be based on many hundreds of observations, and the stations providing the observations should be closely spaced and well distributed over the area to be studied. A number of properly trained people must be employed to guide the work and to initiate and promote research leading to the application of the climatological findings to specific farm problems. Other needs such as funds and consultation with the best men in other agricultural sciences are apparent.

The most promising source of the required consultation is the state agricultural colleges and the agricultural experiment stations. Funds are always a problem, but seldom an insoluble one. Federal cooperation is available (Sarle, 1946), both in terms of finances and in terms of assistance with the provision and analysis of data by the punched-card method. Unfortunately only a small number of properly trained meteorologists are available for the supervisory work. This difficulty will disappear as men now in training become available and as the field produces a demand for their services. A program of in-service training for young scientists should be organized as early as possible in the life of any given unit.

Small beginnings have been made at scattered points throughout the country. In Iowa work has been done principally on the occurrence of frosts. In North Carolina a "pilot project" designed to "determine successful substitute crops for cotton from the standpoint of climatic probabilities in part of the upper Piedmont area" has been operative. One important need is for a much more general and concerted attack on the research. The nature of weather is such that its continuity both in space and time is a major factor in judging its behavior. This fact should emphasize the importance of establishing a fairly complete climatology for the entire continent as a step in the process of developing a well-founded science of agricultural meteorology.

LIMITED LONG-RANGE FORECASTING

The science of weather forecasting has also advanced somewhat since the publication of "Climate and Man". Of special interest here is the "experiment . . . in limited long-range forecasting" which has developed into the Extended Forecast Section of the U. S. Weather Bureau (Namias, 1943). From this group in Washington extended forecasts are sent out twice weekly for publication at the discretion of the regional offices of the Weather Bureau. The forecasts published on Tuesdays cover the period Wednesday through Sunday, and those published on Fridays cover Saturday through Wednesday. These particular periods and times of publication might not be the best possible for agricultural purposes, but a more important consideration is that these forecasts, covering periods of 5-days' duration and published the day before the beginning of the forecast period, are regularly available.

Although the utility to agricultural industry of such forecasts has long been recognized, to date relatively little has been done to apply the extended forecasts to the benefit of agriculture. Probably the greatest obstruction to the production of extended agricultural forecasts is the poor liaison between the agricultural and meteorological sciences. *It is precisely this liaison which falls into the special realm of agricultural engineering.* Since the agricultural engineer is trained both in agriculture and in physical science, he is the person best prepared to make the required adaptations.

It is vital at this point to emphasize the essential differences between the customary daily weather prediction and this longer period forecast. Of necessity the precision of forecasts is an inverse function of the time period over which they are projected. The 24-hour forecast is one based on a thorough consideration of the velocity and intensity of each storm and/or potential storm on the weather map. In short, it is taken from the forecaster's prognostic chart, i.e., his best estimate of what the weather map will be 24 hours hence. The extended forecast is an entirely different concept. It is based on a forecast of the large-scale features of the atmospheric circulation for the period in question. Such large-scale features actually define the areas of storminess, on the average, over the forecast period. Thus the forecaster upon reference to his extended prognosis can predict the occurrence of above, below, and near normal *mean* temperature and precipitation for the period, without depending too heavily on his ability to foresee the day to day behavior of individual storm centers throughout the period.

The forecast of mean anomalies of weather elements, in conjunction with an estimate of the day to day behavior of individual storms, permits a prediction of both the total precipitation for the period and its distribution throughout the period in a given locality. The same applies as well to temperature. To date precipitation and temperature are the principal weather elements treated; however, in a program designed to adapt the forecasts for agricultural uses it would be feasible to investigate the prediction of other quantities such as per cent of possible sunshine, occurrence of strong winds, etc., for regions where such forecasts may be desired. The importance of this type of information in the great agricultural areas of the nation is immediately apparent. During seedtime, haying, and harvest, the forecast of a dry 5-day period, or of two wet days followed by three warm and dry days, etc., etc., is of considerable utility and economic importance. The livestock industry likewise, with lambing, shearing, and a multiplicity of range-grazing problems which are directly associated with weather, has an obvious use for forecasts of this type.

ACCURACY OF EXTENDED FORECASTS

The question of accuracy of the extended forecasts is of immediate interest. During the six years that this type of forecast has been made on a routine twice-weekly schedule by the Weather Bureau, careful studies of the forecast verifications have been made. These studies have revealed that although the forecasts are not perfect, they are appreciably better than chance. They span roughly one-third of the gap between pure chance verification and the best attainable score, i.e., if an arbitrary scale with chance at 50 and best possible at 100 is chosen, the extended forecasts rank about 67. Due to the fact that precipitation forecasts are more difficult than are temperature forecasts, the temperature forecasts generally verify somewhat better than do the precipitation forecasts; however, the history of the extended forecast method indicates a more rapid improvement of forecasts of precipitation than of temperature.

There is reason to believe that the verification rank of extended forecasts would be improved in the process of applying them to agriculture in specific areas. Again, as in the case of climatology, it is a matter of adapting the forecasts to relatively homogeneous areas, that is, regions practicing a uniform type of agriculture or regions of fairly uniform soil type. The Weather Bureau forecasts cover the entire continent. They outline on a broad scale, as suggested by the term "large scale circulation", the weather over the United States. In so doing the weather over the entire western half of the northern hemisphere is considered. It is not feasible for the organization in Washington to give special attention to areas the size of counties or even individual states in its forecasts. Neither is it feasible for the regional offices of the Weather Bureau to make special agricultural adaptations of the extended forecasts. A special agency set up specifically to deal with agricultural meteorology is required if these services are to be accomplished satisfactorily.

An appropriate organization for this purpose would be one designed to meet the requirements of a single state or agricultural region. This organization would (1) pursue a program

of climatological research designed to meet the special agricultural problems of the area, (2) cooperate with agricultural experiment station personnel in the pursuit of all research designed to establish relationships between the several weather elements and the various elements of agriculture, and (3) adapt and apply such weather information and services as are available to the special farming problems of the region.

In association with the state agricultural colleges, such an organization might provide employment for a limited number of promising students. An in-service training program would be necessary at the outset in order to provide sufficient numbers of trained personnel. In view of the fact that the research to be done involves every branch of agricultural science, it is difficult to estimate the importance and extent of the ultimate program.

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Permeability Characteristics

(Continued from page 150)

These soils are much more permeable to Sevier River water than they are to the tap water. The highly saline soils from the abandoned area are much less permeable than the soils from the alfalfa field. The subsoils in both instances are less permeable than the surface soils. This might not be true of field conditions where the subsoil is undisturbed. Other experiments have indicated that the subsoils in their undisturbed condition may be much more permeable than is indicated by tests on disturbed soil samples. Soil 700 when leached with both waters exhibited an unusual characteristic not frequently observed. After leaching started, the permeability increased appreciably during the first three to four days, more than doubling the initial rate. With tap water it then decreased slightly to the first minimum value before again increasing upon elimination of air. This first rise took place during the same period when a very decided decrease occurred in the permeability of the surface soil 697 with tap water.

There was a similar slight increase in permeability of soil 698. These initial increases may have occurred during the time the gypsum in the soil was being dissolved, and are possibly due to the exchange of Ca for Na in the exchange complex, and perhaps also in part to additional pore space resulting from the removal of the salt. Although the permeabilities of the saline soils with river water were quite low, there was no appreciable decrease in permeability during the first phase of the test as occurred with both surface soils when leached with tap water.

SUMMARY AND CONCLUSIONS

The tests reported emphasize (1) the effect of water composition on soil permeability; (2) that soil permeability is not constant but changes appreciably with time; (3) that these changes are explainable. These and other experiments which have been conducted at the Salinity Laboratory reveal certain characteristics of saline and alkali soils. The influence of water composition on permeability of soils is very pronounced, but is generally overlooked when permeability tests are made[4]. Still greater differences would have been observed had tests with distilled water been included.

These tests emphasize the importance of the composition of irrigation water used for field leaching purposes. The use of waters of very low salt content may result in soil sealing to such an extent that reclamation is not feasible, whereas a water of medium to high salt content might prove satisfactory. Amendments such as gypsum are very effective on some soils in preventing sealing, but are not required on others. The difference in permeability of a saline and non-saline soil when leached with a low salt water explains why saline areas frequently persist in a field and are not reclaimed by normal irrigation practices. The soils in the saline areas are of such low permeability that little water enters them during the time of contact, most of the water applied entering the more permeable non-saline areas. Reclamation of these saline areas might be achieved if these spots were isolated and flooded for long periods.

The changes in permeability that occur with time, and the effect of water composition, are both probably due to changes that occur in the dimensions of the pore space, D (equation [3]). When water is first applied, dispersion and swelling occur, resulting in a decrease in D. The water composition markedly affects this swelling and dispersion. The mean value for D increases again when the air entrapped in the larger pores is dissolved. Upon continued percolation, the products of microbial activity again seal some of the pores and decrease D.

Because the permeability is not constant, and there is an interaction between the water and the soil, there appears to be little advantage in trying to separate the factors making up the permeability, P, by eliminating those factors relating to the fluid. The assumption is frequently made that, if the permeability coefficient includes only those factors relating to the porous medium, it will be universally applicable to any fluid such as water, oil, or gas. This is certainly not true for soils where small differences in water composition, which has negligible effect on the density and viscosity of the fluid, markedly changes the pore structure and permeability. An over-all permeability factor such as the Darcy coefficient, P, is believed to be the most useful for soils work.

ACKNOWLEDGMENTS: The assistance and cooperation of the U. S. Regional Salinity Laboratory staff is gratefully acknowledged. Special thanks are due Drs. L. E. Allison, L. A. Richards, and Milton Fireman, and Director H. E. Hayward for their constructive criticism of the manuscript.

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Comparative Efficiency of Ensiling, Barn Curing, and Field Curing Forage Crops

By R. E. Hodgson, J. B. Shepherd, W. H. Hosterman, L. G. Schoenleber, H. M. Tysdal, and R. E. Wagner
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FORAGE crops furnish an important and essential part of the feed needed on every dairy farm. As a rule, the crops grown and harvested for roughage furnish feed nutrients at a lower cost than the home-grown grain crops. Since harvested roughages make up a large part of the winter ration of the milking herd, the roughage should be of the highest quality possible. High-quality roughage furnishes a greater part of the nutrients required by the dairy cow than low-quality roughage and, when high-quality roughage is fed, less supplemental feed is needed. Quality varies greatly with the method of harvesting, handling, and storing the crop, and differences in quality reflect differences in feeding value that result from losses of feed nutrients during harvesting and storage.

The milk-producing value of roughage depends not only on the kind of crop and its stage of maturity and condition at the time it is harvested, but also on the weather conditions at harvesting time, the harvesting methods used, and the manner in which the crop is stored. It is generally considered that forage crops should be harvested at a relatively immature stage to produce roughage of the highest feeding value. Harvesting methods that permit getting the forage into storage with the least handling and in the shortest possible time conserve the most feeding value. Unfavorable weather (rain, high humidity, and cloudy skies), slow, inefficient harvesting methods, and poor storage conditions increase the losses of dry matter and nutrients and lower the feeding value of the resulting roughage.

Farmers generally have at their disposal three practical ways of harvesting and preserving the forage grown for the winter feeding period, namely, field curing the crop into hay, partial field curing followed by barn curing, and making the crop into silage. The method or combination of methods that will economically produce the highest quality feed with the least loss of nutrients should be used. The method favored by most farmers in a locality may vary with the locality and in some instances it may vary with different cuttings of the same crop in the same locality.

Farmers do not have enough information about the efficiency of these three methods to guide them in choosing the best method. For this reason investigations were undertaken at the Agricultural Research Center of the U. S. Department of Agriculture to determine the relative efficiency of these three practical methods of harvesting forage for the winter feeding period. The investigations will be continued over several years to compare the efficiency of these three methods under the usual variations in weather conditions that come with different seasons. This preliminary report describes the first year's experiments and is made available to acquaint those interested with the trend of results in this important field of forage preservation.

How Experiment Was Conducted. The first two cuttings of alfalfa, both of which contained about 15 per cent of Ladino clover, were harvested for this experiment in 1945. For each cutting the field was divided into several separate areas, each of which was subdivided into three long strips so as to provide comparable areas and forage to be harvested and stored as field-cured hay, as barn-cured hay, and as silage. The crop was cut when the alfalfa plants were one-tenth to one-fourth in bloom and all three strips were cut at the same time. However, raking, loading, and storing operations for each method of harvest were performed when the forage was in proper condition for the method concerned. The forage was sampled as it was cut, to obtain a measure of the yield and composition of the crop. The yield and composition were also determined when the forage was taken off the field and put into storage, and again when it was taken out of storage for feeding.

The forage was cut with a tractor mower, windrowed with a side-delivery rake, loaded with a heavy-duty, double-cylinder loader, and hauled to storage on trucks. A record was kept of the labor and machinery required to harvest the crops by each method. The field-cured and barn-cured hays were stored in mows. The barn-cured hay was stored over a system of air ducts which delivered air over the mow floor and forced it through the hay for drying. The air forced through the mow to dry the barn-finished hay was heated for the first cutting but not for the second cutting. The silage from each cutting was made in a tight, smooth-walled cement stave silo with no preservative added[1]. The cutter was set to chop the forage in ¼-in lengths.

While the first cutting was being harvested the weather was generally favorable except for the last part of the period when about half of the field-cured hay received 0.66 in of rain. Good haying weather prevailed throughout the period when the second cutting was harvested.

How Harvesting Methods Compared. The average mois-

[1]Shepherd, J. B. How to put up wilted grass silage. U. S. Bureau Dairy Industry, BDIM-Inf-38, 5 pp., 1946. (Processed)

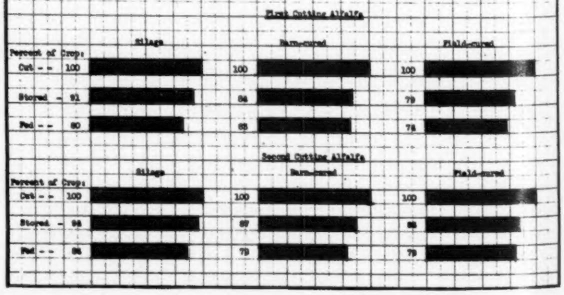


Fig. 1 Effect of method of harvesting and preserving on dry matter yield per acre of alfalfa

This paper was presented at the Third Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Chicago, Ill., December, 1946. It is a report of the preliminary results of an investigation being conducted cooperatively by the Bureau of Dairy Industry and the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, and the Production and Marketing Administration, U. S. Department of Agriculture. The authors were assisted in the research by L. A. Moore, H. G. Wiseman, and C. G. Melin of the Bureau of Dairy Industry, and by T. E. Hienton and M. A. Hein of the Bureau of Plant Industry, Soils, and Agricultural Engineering.

R. E. HODGSON and J. B. SHEPHERD are of the Bureau of Dairy Industry; W. H. HOSTERMAN is of the Production and Marketing Administration, and L. G. SCHOENLEBER, H. M. TYSDAL, and R. E. WAGNER are of the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

TABLE 1. LABOR AND MACHINERY HOURS REQUIRED IN HARVESTING AND STORING ALFALFA

(Per ton of dry matter fed)

Items compared	Alfalfa harvested and stored as		
	Silage	Barn-cured hay	Field cured hay
First-cutting alfalfa, 1945*			
Man-hours	4.95	4.45	4.51
Tractor-hours (all operations)	1.39	1.34	1.86
Mower-hours (tractor operated)	0.50	0.52	0.58
Rake-hours (tractor operated)	0.43	0.50	1.00
Loader-hours (truck drawn)	0.61	0.51	0.44
Truck-hours (loading, hauling, unloading)	1.81	1.33	1.16
Silo-filler-hours (tractor operated)	0.46		
Hay-hoist-hours (tractor operated)		0.33	0.27
Fan-operation-hours†		13.3	
Supplemental-heat-hours‡		12.1	
Electricity (kilowatt-hours)		71.6	
Second-cutting alfalfa, 1945**			
Man-hours	4.76	5.15	4.58
Tractor-hours (all operations)	1.32	1.43	1.49
Mower-hours (tractor operated)	0.48	0.50	0.52
Rake-hours (tractor operated)	0.36	0.43	0.63
Loader-hours (truck drawn)	0.47	0.42	0.54
Truck-hours (loading, hauling, unloading)	1.56	1.41	1.34
Silo-filler-hours (tractor operated)	0.48		
Hay-hoist-hours (tractor operated)		0.50	0.33
Fan-operation-hours††		25.6	
Electricity (kilowatt-hours)		83.7	

*Harvested May 14 to 18. Yield of standing crop, 0.97 ton of dry matter per acre.

†The type of fan available for use with the first cutting was not well suited for mow drying. It delivered only 6 to 8 cfm per sq ft.

‡Temperature of air in main duct raised about 40 F above atmospheric temperature.

**Harvested June 25 to 29. Yield of standing crop 1.08 tons of dry matter per acre.

††Fan delivered 15 to 16 cfm per sq ft at atmospheric temperatures and humidity.

ture content of the field-cured hay when it was stored was 21.7 per cent for the first cutting and 19.2 per cent for the second cutting. Both hays graded U. S. No. 2 alfalfa clover mixed.

The barn-dried forage contained 37.3 per cent and 43.6 per cent of moisture, respectively, for the first and second cuttings, when it was taken off the field. The first cutting was placed in the mow to a depth of 5 ft and dried in 4 days with air that was heated to increase the temperature by about 40F (degrees Fahrenheit). The second cutting was placed in the mow to a depth of 9 ft and dried in 13 days with outside, unheated air. The first cutting was dried down to an average moisture content of 10.5 per cent, and the second cutting to an average of 12.7 per cent, while on the drier. These hays graded, respectively, U. S. No. 2 leafy extra green alfalfa clover mixed and U. S. No. 2 extra leafy alfalfa clover mixed.

The forage made into silage by the wilting method contained 62.2 per cent of moisture for the first cutting and 60.6 per cent of moisture for the second cutting when ensiled. Both were classed as excellent in quality, with about 50 per cent leaves, a good aroma, and high palatability.

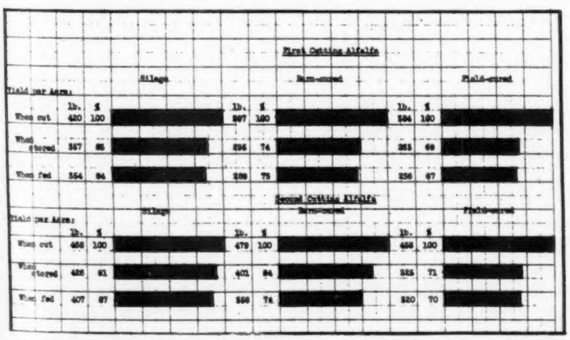


Fig. 2 Effect of method of harvesting and preserving on the protein yield per acre

The labor and machinery hours required to harvest and put the crop into storage are summarized in Table 1. Only the actual operating time of the various harvesting operations is included.

Considering both cuttings, tractor, mower, and rake requirements were lowest for silage and barn-cured hay and highest for field-cured hay. Loader requirements were about the same for all methods. Truck requirements were lowest for field-cured hay and highest for silage. Silo filler requirements were slightly higher than hay hoist requirements. Balancing these differences, equipment requirements for harvesting and storing were no higher for making wilted alfalfa silage or barn-cured hay than for making field-cured hay. Labor requirements per ton of dry matter as fed were about the same for silage and for barn-cured hay, and only slightly higher for both than for field-cured hay.

Fan operation and supplemental heat used in barn drying constitute extra items and expense not required for silage or for field-curing hay.

The differences in the dry matter yield of the forage made into silage, barn-cured hay, and field-cured hay for the two cuttings are shown in Fig. 1. Averaging the results for the two cuttings shows that 92.5 per cent of the original crop used for silage was taken off the field and 82.0 per cent was fed. Compared with this, 85.5 per cent of the forage barn cured was taken off the field and 81.0 per cent was fed, while for the field-cured hay only 81.0 per cent was taken off the field and 76.5 per cent was fed. This represents 5.9 per cent and 7.2 per cent more dry matter available for feeding from barn-cured hay and wilted silage, respectively, than from field-cured hay.

TABLE 2. PROTEIN CONTENT OF FORAGE HARVESTED AS SILAGE, BARN-CURED HAY, AND FIELD-CURED HAY

(Dry matter basis)

Cutting and sampling time	Silage, per cent	Barn-cured, per cent	Field-cured, per cent
First cutting:			
When cut	20.89	21.04	20.44
When stored	19.46	18.59	17.66
When fed	21.97	18.35	18.43
Second cutting:			
When cut	21.86	21.70	21.58
When stored	21.34	20.81	18.56
When fed	22.62	20.37	19.26

The protein content of the dry matter of the two cuttings harvested the three different ways is given in Table 2. Averaging the results for the two cuttings shows that the silage when fed contained about 12 per cent more protein than the field-cured hay (on the dry basis), while the barn-cured hay contained only 2.7 per cent more protein than field-cured hay.

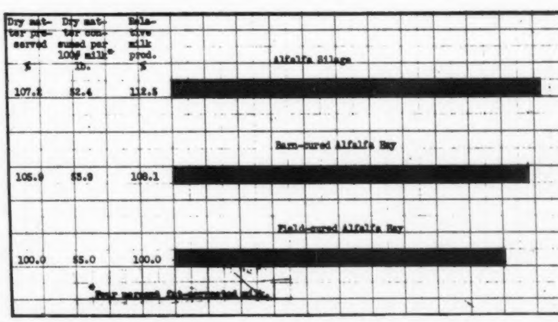
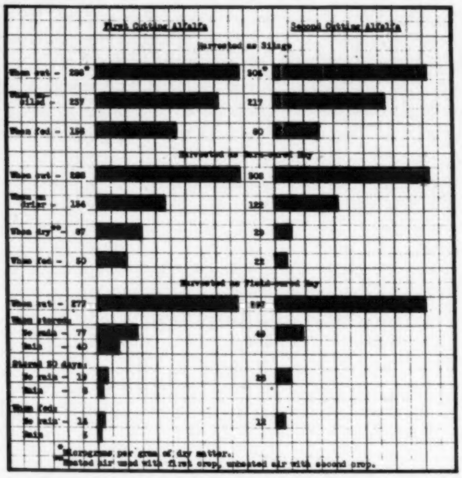


Fig. 3 Indicated milk yields per acre from alfalfa when harvested on wilted silage, barn-cured hay, and field-cured hay. In addition, corn silage and concentrates were fed at the rate of 0.28 lb and 0.50 lb of dry matter, respectively, with each pound of alfalfa dry matter.



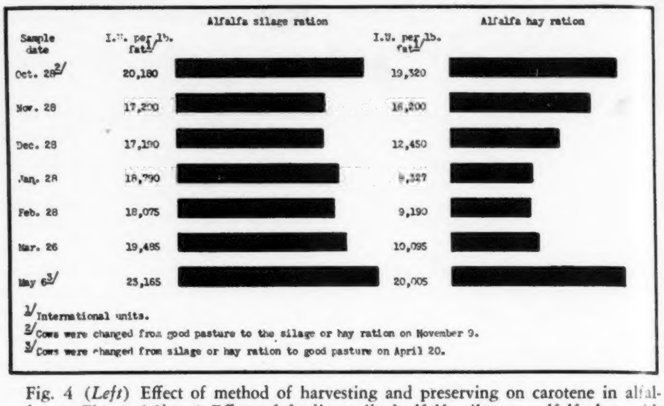


Fig. 4 (*Left*) Effect of method of harvesting and preserving on carotene in alfalfa • Fig. 5 (*Above*) Effect of feeding wilted alfalfa silage or alfalfa hay with corn silage and concentrates on the vitamin A content of the butterfat

According to Fig. 2, which shows the changes in the yield of protein, this nutrient was saved much more efficiently by making the forage into silage. The silage method saved an average of 86 per cent of the protein of original crop for feeding, compared with 74 per cent for the barn-cured method and only 68 per cent for the field-cured method. Thus the protein loss was reduced by more than one-half by making silage.

Results of Feeding Experiment. The three kinds of roughage made from the second cutting were fed to milking cows, along with corn silage and concentrates, in a controlled feeding experiment. As shown in Table 3, the cows produced slightly more milk (3 per cent), gained more in live weight, and produced 100 lb of milk at a lower feed requirement when they received the alfalfa silage than when they received either kind of hay[2]. Except for a smaller gain in live weight on the barn-cured hay, the cows did about as well on one hay as on the other. The alfalfa silage was very palatable and the cows consumed as much dry matter from it as from the hays. The cows consumed 4.7 per cent and 2.0 per cent less alfalfa dry matter per 100 lb of 4 per cent fat-corrected milk produced, on the wilted silage and barn-cured hay rations, respectively, than on the field-cured hay ration.

TABLE 3. COMPARATIVE VALUE OF THE SILAGE, BARN-CURED HAY AND FIELD-CURED HAY FOR MILK PRODUCTION

Item	Wilted silage ration	Barn-cured hay ration	Field-cured hay ration
Milk production (4 per cent fat-corrected milk):			
Average per day, lb	32.8	31.9	31.8
30-day decline, per cent	4.3	10.0	5.9
Live weight, lb			
Average	1,097.0	1,084.0	1,087.0
Daily gain	0.47	0.03	0.40
Feed dry matter consumed per day, lb:			
Alfalfa silage or hay	17.2	17.2	17.5
Corn silage	4.9	4.8	4.9
Concentrates	8.4	8.8	8.6
Total	30.5	30.8	31.0
Feed consumed per 100 lb 4 per cent fat-corrected milk, lb:			
Alfalfa dry matter	52.4	53.9	55.0
Total dry matter	92.9	96.5	97.4
Total digestible nutrients	63.0	66.0	65.7

When the difference in the losses of dry matter occurring with the three methods of harvesting and preserving the forage (average for both cuttings) and the differences in the milk production by cows fed the three roughages from the second cutting along with corn silage and concentrates are considered together, it is shown in Fig. 3 that by making the crop into silage 12.5 per cent more milk per acre was obtained than when it was made into field-cured hay. There is an 8.1 per cent advantage for the barn-curing method over field curing.

The changes that occurred in the carotene content of the forage made into the three feeds are shown in Fig. 4. The carotene content of the silage when fed was much higher than either of the hays, for both cuttings. The two cuttings of barn-cured hay when fed averaged about twice as high in carotene as the field-cured hay. The first cutting of barn-cured hay was much higher in carotene after drying than the second cutting. This was because heated air was used for the first cutting and the drying time was only about a third as long as for the second cutting when no heat was used.' Important losses occurred in the hay after drying was completed. The portion of first-cutting field-cured hay that was rained on had less than half as much carotene as the portion that was not rained on.

The silage method is a good way to conserve carotene. The importance of saving this nutrient is indicated in Fig. 5 which shows the vitamin A value of the butterfat produced by cows fed the first-cutting silage compared with other cows fed a good quality of U. S. No. 2 alfalfa hay. Both groups of cows received corn silage and concentrates in addition. The vitamin A value of the butterfat produced by the cows fed the alfalfa silage remained relatively close to the pasture level throughout the winter, whereas that produced by the cows fed the hay gradually decreased to less than half the summer level. The cows that received the silage ration all winter did not go off feed, but consumed large quantities of the silage and remained in good physical condition.

SUMMARY

The results of these studies, though preliminary, strongly suggest that significantly larger amounts of dry matter, protein, and carotene can be obtained by making forage into silage rather than by making it into either field-cured or barn-cured hay. In this experiment the silage had more value for milk production and produced milk of much higher vitamin A value than either kind of hay. These advantages were obtained with very little if any additional labor or use of machinery for harvesting and preserving the crop. The barn-curing method, while not as efficient as the silage method, was considerably more efficient than field curing but required the additional expense of fan operation. These advantages of the silage and barn-curing methods might have been considerably greater if rainy weather had occurred during the harvesting periods.

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The Aims and Objects of Higher Education

By Dr. A. A. Potter

FROM its very beginning, the builders of this country have encouraged education in order that an educated electorate may be available to insure success for our type of government. American higher education has been influenced partly by English patterns which stressed moral development, partly by French technical education which emphasized professional competence, and mainly by German higher education where scholarship and research are the major objectives.

It became evident early in the last century that American higher education, which concerned itself mainly with the classical and traditional studies, did not prepare people to attack the national problems of agriculture, industry, and transportation. The classical type of education, imported from Europe, had no relation to the resources of the country or to the occupations and objectives of the great mass of the people. Thomas Jefferson, in the charter of the University of Virginia, in 1818, defined a university as "an institution in which every branch of knowledge useful at this day is taught in its highest degree." The practical vision of Thomas Jefferson was shared by few of his contemporaries. The people during the early days of this republic knew little about science and its applications.

The demand for scientific education to increase production in agriculture and industry resulted in the establishment of the Rensselaer Polytechnic Institute, at Troy, New York, in 1824, to teach "the applications of science to the common purposes of life." Launched as an agricultural school, the Rensselaer Polytechnic Institute, with the introduction of instruction in civil engineering in 1829, was the first civilian engineering school in the English-speaking countries.

In 1845, Jonathan B. Turner became active in Illinois, advocating higher education for the industrial classes and the organization of industrial universities. Turner proposed, in 1852, that Congress provide a land grant to each state for the establishment of industrial universities adequate to create and endow, in the most liberal manner, a general system of industrial education, "more glorious in its design and more beneficial in its results than the world has ever seen before."

The first Morrill Act of 1862, signed by President Abraham Lincoln, provided for the establishment of a comprehensive system of colleges to teach the applications of science. This act gave to each state 30,000 acres of public lands for each senator and representative to which it was entitled in Congress. The money derived from the sale of these grants was to constitute an endowment fund, the interest of which was to be used to support "at least one college, where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such a manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." The institutions resulting from this act are known as "land-grant colleges."

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The success of the land-grant colleges may be traced to the provision for the creation of a permanent endowment through grants of public lands for the organization and support of these colleges, to the placing of an obligation upon the states to maintain intact the capital fund of the endowment, and to the emphasis upon "education of the industrial classes."

The first Morrill Act was followed by other legislation in the interest of the land-grant colleges. Outstanding examples of such legislation are (1) the Hatch Act of 1887, which provided funds for agricultural research; (2) the second Morrill Act of 1890, which appropriated additional funds for the support of instruction; (3) the Adams Act of 1906, which increased the appropriations for agricultural research, and (4) the Smith-Lever Act of 1914, which encouraged extension programs in agriculture and home economics.

The land-grant act had a most profound effect upon all types of education by changing the emphasis from language, logic, and philosophy to science, technology, and industry; from a verbalistic and speculative to a factual and useful education; from deductive to inductive reasoning, and from the accepted to the analytical process.

The land-grant act has broadened the scope, objectives, and services of higher education. The colleges created under that act are not merely teaching institutions, but are also public service institutions: they serve not only the individual, but also the state, the nation, and the public at large.

The land-grant colleges have developed on the part of the states a sense of responsibility for higher education of a practical nature, and a realization that education is a developmental function of interest to the public, in which the state and the nation may cooperate. These institutions have perfected a type of education upon which is dependent the permanent welfare of the people. Agriculture, engineering, and homemaking form the basis of national prosperity and happiness. The majority of our leaders in agriculture and home economics are graduates of land-grant colleges. Even in engineering, by far the largest number are graduates of these institutions.

The land-grant colleges, which rest upon the foundations of state and national beneficence, realize that the stability of a democracy depends upon the prowess and qualities of the people. The type of education which is represented by these typically American colleges, has strengthened the character of thousands of men and women by developing in them the power of scientific analysis, so that they are able to approach problems with an open mind, without prejudice and preconceived notions. All land-grant college curriculums have a disciplinary value in teaching the student industry, seriousness of purpose, and the importance of useful service to humanity. Some of the studies have developed habits of accuracy, system, and thoroughness; other courses have instilled a love for nature and an appreciation of the responsibility of the individual to the community. The home economics curriculums have resulted in improving the homes of the nation by bringing about a greater realization on the part of young women of the nobility of homemaking as a career.

In addition to the Morrill land-grant act, from which engineering education has received its greatest impetus, the following factors are significant:

The American Society for Engineering Education (formerly the Society for the Promotion of Engineering Education), founded in 1893, has been an important medium through which the development and improvement of engineering edu-

cation has been carried on. The self-appraisal of engineering colleges through the A.S.E.E. Investigation of Engineering Education from 1923 to 1927 and the Summer Schools for Engineering Teachers (1927 to 1933), which resulted from this study, have had a most beneficial effect in focusing attention upon improving engineering curriculums, teaching methods, engineering educational policies and practices, and cooperative relationships between the engineering colleges, industry, and the engineering profession. Another report of the A.S.E.E. on Aims and Scope of Engineering Curriculums, published in 1940, has aided in encouraging the parallel development of scientific-technological and humanistic-social sequences in engineering programs of study. The A.S.E.E. report on engineering education after the war (1944) has been helpful in planning curriculums to prepare engineering graduates for courses in operation and management of industry, as well as for creative and scientific posts. Finally, the report of the A.S.E.E. Committee on Graduate Study (1945) has developed a perspective recognizing the growing importance of graduate study in engineering as preparation for the more creative careers.

E.C.P.D. (Engineers' Council for Professional Development), a functional body of the engineering profession, representing the major engineering societies, has been helpful in enhancing the preparation, services, and standing of the engineer. The E.C.P.D. has appraised for the engineering profession, through its Committee on Engineering Schools, the engineering programs of study of colleges and universities, and has set up a list of accredited engineering curriculums for use by government agencies, state licensing boards, industries, engineering societies, and educational institutions. Its inspection procedures have been helpful in improving entrance requirements, curriculums, teaching methods, institutional physical plants, and have given administrative officers a better appreciation of the objectives of engineering education. The E.C.P.D. Committee on Selection and Student Guidance has been helpful in improving the quality of those who enter upon the study of engineering, and its Committee on Professional Training has encouraged the young engineering graduate to continue his studies and his preparation for greater service to society.

SCIENCE AND TECHNOLOGY A "MUST"

The outstanding technological developments of the past eighty years have gone on simultaneously with a more general appreciation of engineering and scientific education. Recent war years have focused special attention upon science and technology supplying the type of knowledge that is essential to waging modern war. More science and more technology is an absolute "must" for a nation to maintain its place in a warlike world. Only more and better engineering and science can repair the damages of war; can make our country self-sufficient with regard to strategic materials; and can insure our people full employment and high living standards.

Among the factors which are bound to influence in the future all types of higher education, particularly engineering education, the following are worthy of consideration:

The junior colleges are growing in number, in importance, and in the character of their programs. The intensive war training programs on the college level, developed to train technicians and assistants to scientists, engineers, and production supervisors, have focused the attention of about one and one-half million people upon practical education of the technical institute type. To what extent should colleges and universities adapt their curriculums to the junior college and technical institute type of program?

Adult education has received a great impetus by the war-training programs and by the special schools conducted by our armed forces. To what extent are higher educational institutions making use of their interests in adult education to broaden and to afford advanced preparation to employed college graduates?

American creative talent is largely responsible for the epoch-making inventions of the past century. The telegraph, telephone, electric light, airplane, sewing machine, typewriter, phonograph, cinema, harvester, reaper, cotton gin, safety razor, fountain pen, camera, and at least one-half of the other great inventions of our times were made by Americans. All types of education, particularly engineering and scientific curriculums, must equip the youth of our country with the tools of invention and must stimulate their creative efforts to develop new materials, machines, and processes to enhance human comfort and to elevate living standards. The tools of modern invention are mathematics, science, and technology, and these tools, if kept at a high level of effectiveness, will not only result in greater inventiveness, but may even insure peace by convincing people the world over that scientific and technological knowledge is cheaper than mechanized warfare, and that a nation can obtain abundant life and self-sufficiency through research and invention much cheaper and safer than through banditry, treachery, and war.

The high level of inventiveness of Americans may be traced to our Constitution which emphasized and idealized the rights of the individual above those of the State. Totalitarian governments, which restrict individual freedom and make men the tool of the State, do not excel in inventiveness.

AMERICA INDUSTRIALLY SUPREME

The industrial supremacy of America and the high living standard of our people may be traced largely to the fact that for over 150 years this country has had the best government in human history — a government which encouraged its citizens to create more, to produce more, and to have more than any other peoples in the world — a government which has looked upon the making of profit with approval and which has given maximum encouragement to individual freedom and private enterprise — a government which is the agent and not the master of the people — and a government which exists to serve and not to dictate to its citizens.

It is a major responsibility of all education to impress upon our people that our country's future depends upon the extent to which the most able, the best educated and the clearest thinking of our citizens interest themselves in good government. Our young people must be made to realize that their very existence and usefulness in their chosen life's work depend upon the form of government under which they live and work. To have good government, all must be willing to give of their time and of their talents to insure that only those who are competent are elected to public office and are given full support to discharge their responsibilities. The best educated of our people must work for the enhancement of the American way of life through good government.

Finally, it must be realized that the best education and the most improved science and technology do not by themselves insure security, peace, and happy living in a world where human values are not fully appreciated and protected. Our world must be built upon law, honor, decency, and kindness, and not upon banditry, deceit, force, and sadism. The future of our civilization depends upon people who have the vision, wisdom, and knowledge to turn new scientific knowledge and education into devices and agencies which add to human happiness and which protect sanctity of all men and women.

Higher education has a responsibility to develop well-educated people who are not only competent and creative, but who are also good and effective citizens — men and women who have character, who act nobly toward others, and who feel most for their fellow human beings.

Simplification in Dairy Production

By Paul R. Hoff
MEMBER A.S.A.E.

THIS paper is a progress report on simplification in dairy production, since the New York dairy project is still active. It can be divided into two parts: (1) the time and cost studies of different methods of handling hay, and (2) the simplification of dairy barn chores. The hay studies were started several years ago and since the year to year results checked closely, it has not seemed necessary to carry it further except as changes in new equipment occur. Results of the hay studies have been presented to members of this society at several meetings by Dr. Ivan R. Bierly, of the agricultural economics department, who directs the Farm Work Simplification Project at the New York State College of Agriculture. The studies were made cooperatively by the departments of agricultural economics, agronomy, and agricultural engineering, at that institution.

A previous farm management study*, which showed that about one-half of a New York dairyman's time is spent doing barn chores, indicated a need for a study aimed at increasing labor efficiency in the dairy barn. Accordingly time and travel studies were made in 17 dairy barns during 1944. These studies revealed that three important factors affect the amount of time spent in milking, caring for the milk, and caring for the herd.

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1946, as a contribution of the Farm Structures Division.

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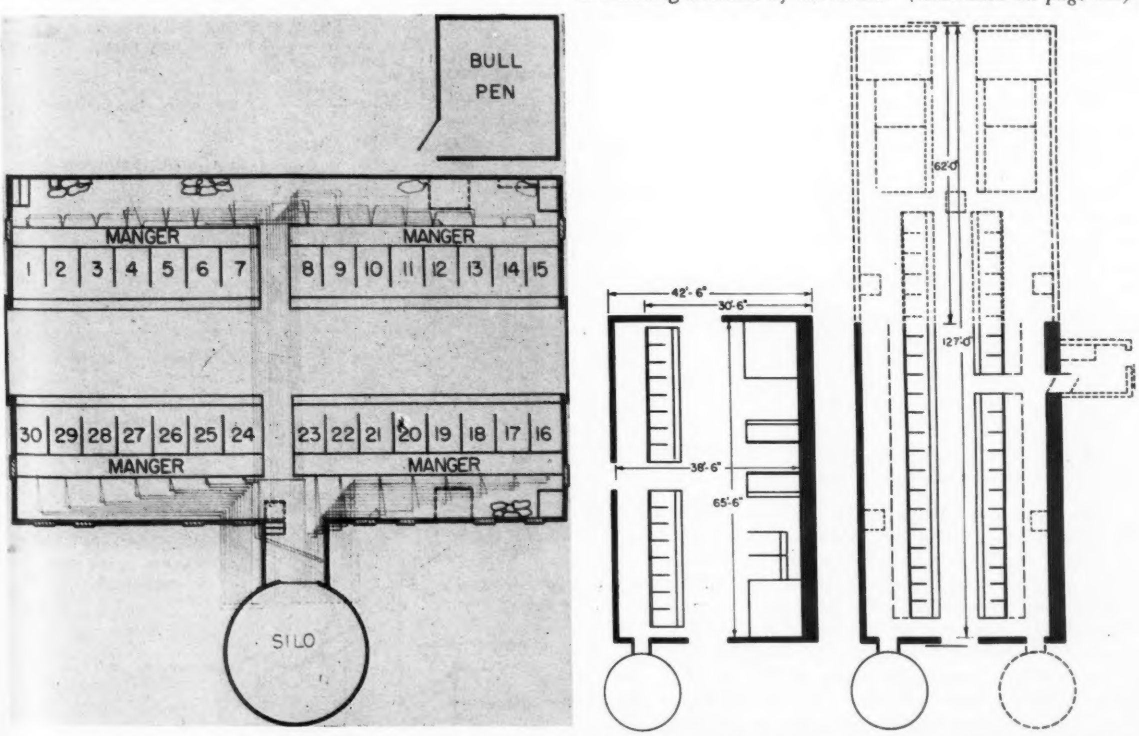
*Unpublished summary of farm cost account records in New York.

They were (1) the arrangement of the dairy stable and the location of the milk house, (2) the use of labor-saving equipment, and (3) developing a work routine so that the operator works while he walks and uses equipment as efficiently as possible. None of these factors are new, but the study emphasizes their importance in dairy barn efficiency.

The arrangement of the dairy stable determines to a considerable extent the way in which work is done. It is the most inflexible of the three factors and the one which most farmers change only once or twice in a lifetime. It may determine the amount and kind of labor-saving equipment that can be used, as, for example, wide cross alleys are necessary to allow the use of ensilage carts. Arrangement also can permit or limit the development of a work routine designed to save labor. As an example, the absence of alleyways at each end of the lines of stanchions may cause needless backtracking during the feeding operation.

Making use of labor-saving equipment is the next important factor in dairy barn efficiency. Probably the milking machine is the greatest single piece of labor-saving equipment. But because it is used on a high proportion of New York farms the important consideration is the way in which the machine is used, and not a comparison of machine and hand milking.

The experience of some of the farmers in the study confirmed experimental evidence and farm experience that practically every cow could be milked out in five minutes or less, and one farmer was milking his cows in about three minutes each. By contrast, some farmers are timing the changing of the milking machine by the fifteen- *(Continued on page 163)*



Left: Travel pattern where each cow's ensilage ration was carried from the silo in a potato crate. Having the bull pen located outside of the stable with no inside entrance is also time consuming • *Right*: Rearrangement of a wide inefficient small barn into a modern dairy barn where the barn work can be done with a minimum of time and travel

Irrigation Sprinkler Characteristics

By C. N. Johnston
MEMBER A.S.A.E.

THE motive power available as the result of reaction forces from water jets is used in the operation of many revolving forms of sprinklers. Most sprinkler jets issue from nozzles, but orifice plates of the sharp-edge or square-edge type could be used. Some of the measurable variables are diameter, pressure or head, thrust, quantity, and characteristic of the stream. This latter factor influences the carrying power of the stream by effecting the breakdown of the jet into drops.

The following data were derived from tests of jets issuing from holes or apertures ranging from 7/64 to 25/64 in in diameter and representing the three types of ports noted previously. The data were obtained using a test unit similar to the one sketched in Fig. 1. The jet issued horizontally and the whole assembly was free to swing on the suspending wires. This tendency to swing under the jet reaction thrust was resisted by adjustment of the spacer on the linkage to the platform scale. The assembly was kept in normal free hanging position over the stationary pointer at the time of reading of the scale. Little or no loss in thrust was present in the linkage due to the use of hard-faced pivoting edges and surfaces. The linkage was so proportioned that a one-pound thrust gave a 5,000-g reading on the pointer of the scale. The supply pipe in the suspended assembly was a 2-in pipe a few inches over 18 ft long. Rectifying baffles were placed in the 3-in inside diameter head, to the outlet of which the orifices and nozzles were attached. The suspending wires were approximately 12 ft long. The head was measured as feet of water pressure at the discharge outlet, the thrust was read in pounds, and the flow or quantity was recorded in pounds per minute by weighing the accumulated discharge for a known time. The quality of jet was ascertained by observation.

The head-thrust relationships for all jets when plotted on linear coordinate paper produce a family of straight lines conforming to the general equation $y = mx$, (see Fig. 2 which shows the nozzles), where y = head and x = thrust, while m is the slope of the line which varies in some relationship to diameter. The value of m or the slope of the head-thrust lines for the various aperture types is listed in Table 1.

TABLE 1. VALUE OF m FOR APERTURE SPECIFIED

Diameter of aperture, in	Nozzle	Square-edge orifice	Sharp-edge orifice* Sharp-edge upstream	Sharp-edge orifice* Sharp-edge downstream
7/64	149.0	245.72	185.7	157.0
5/32	68.1	100.36	78.65	73.7
7/32	35.85	51.69	44.98	35.33
9/32	21.2	31,05	28.1	24.49
5/16	17.65	26.2	23.26	19.76
3/8	12.75			
25/64		17.0	16.98	13.44

*Same orifice used in upstream and downstream positions for each size. Bevel of cut face of sharp-edge orifices 60 deg approximately from line of issuing jet for sharp-edge upstream setting.

The effect of the shape of the aperture is to be noted in the range of m in Table 1. If these data are plotted on full log paper, Fig. 3, segregating the aperture form and plotting diameter against the value of m, four parallel lines are well defined. The general equations for these lines are $\log y = m \log x + \log b$, or $y = x^m b$, where y = diameter, x = slope or m or corresponding head-thrust curve, m = slope of the four parallel lines, and b is a constant varying with the aperture type. The parallel lines drawn through the points on Fig. 3 conform to slope or $m = -0.5$. Original efforts to fit lines to the points showed that a value of $m = -0.48685$ would pass through a few more points. These two possible slopes provide correspondingly different values of b in the general equation as shown in Table 2.

TABLE 2. VALUE OF b

Type of aperture	$m = -0.48685$	$m = 0.5000$
Square edge	1.498194	1.567196
Sharp-edge upstream	1.40129	1.488245
Sharp-edge downstream	1.27915	1.37394
Nozzle	1.234905	1.290365

Because in Table 2 the values are related in the basic equation, $y = x^m b$, to y which is diameter, it is possible to arrive at equations expressing thrust, head, and diameter as follows:

$$m = -0.48685 \begin{cases} \text{head} = \dfrac{1.54247}{\text{diam}^{2.05402}} \times \text{thrust; nozzles} \\ \text{head} = \dfrac{2.29412}{\text{diam}^{2.05402}} \times \text{thrust; square edge} \\ \text{head} = \dfrac{1.999735}{\text{diam}^{2.05402}} \times \text{thrust; sharp edge upstream} \\ \text{head} = \dfrac{1,658132}{\text{diam}^{2.05402}} \times \text{thrust; sharp edge downstream} \end{cases}$$

$$m = 0.5000 \begin{cases} \text{head} = \dfrac{1.672724}{\text{diam}^{2}} \times \text{thrust; nozzles} \\ \text{head} = \dfrac{2.456103}{\text{diam}^{2}} \times \text{thrust; square edge} \\ \text{head} = \dfrac{2.216924}{\text{diam}^{2}} \times \text{thrust; sharp edge upstream} \\ \text{head} = \dfrac{1,887713}{\text{diam}^{2}} \times \text{thrust; sharp edge downstream} \end{cases}$$

Though there is not much difference between the equations using the two values for m, a solution may be arrived at more simply by the use of the value -0.5000.

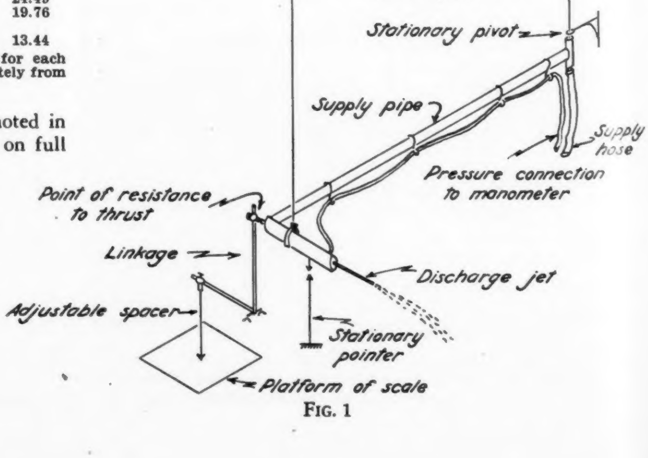


FIG. 1

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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The thrust and the pounds per minute delivered are related variables when the variables, aperture size, and type are constant. When, as in Fig. 4, data from a test of a given aperture type are plotted for the several sizes on a full log graph with thrust and flow on the vertical and horizontal coordinates, respectively, a group of parallel lines results. Here again a general equation expresses the relationships for any given line as follows: log y (thrust in pounds) $=$ m (slope) $\times$ log x (lb per min) $\times$ log b (new variable dependent on diameter).

This general equation has in the term log b a factor that might be expressed as a function of diameter, as in the case

TABLE 3. SOME THRUST IN POUNDS PER MINUTE FLOW RELATIONSHIPS

	Nozzles		Square-edge orifice		Sharp-edge orifice upstream		Sharp-edge orifice downstream	
Diam. of aperture, in	Slope or m of parallel lines	Value of b for parallel lines	m	b	m	b	m	b
7/64	1.94855	.002304	1.96095	.00357791	2.0025176	.00531908	1.9257540	.0045322
5/32	"	.0012345	"	.0015658	"	.00159075	"	.00192203
7/32	"	.0006172	"	.000916702	"	.000855029	"	.000830508
9/32	"	.000382165	"	.00053278	"	.000531908	"	.000581356
5/16	"	.00030417	"	.000432	"	.000417572	"	.000476949
3/8	"	.000215832						
25/64	"		"	.00030563	"	.000298266	"	.000326171

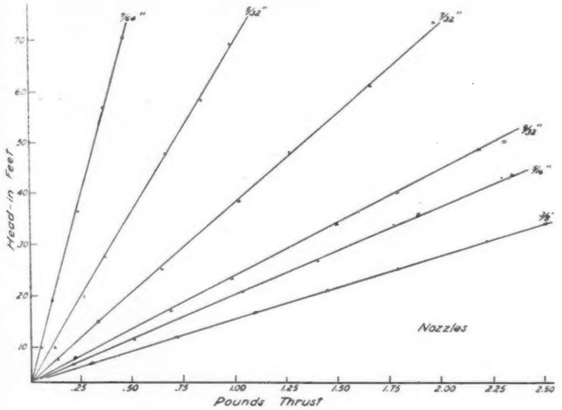


FIG. 2

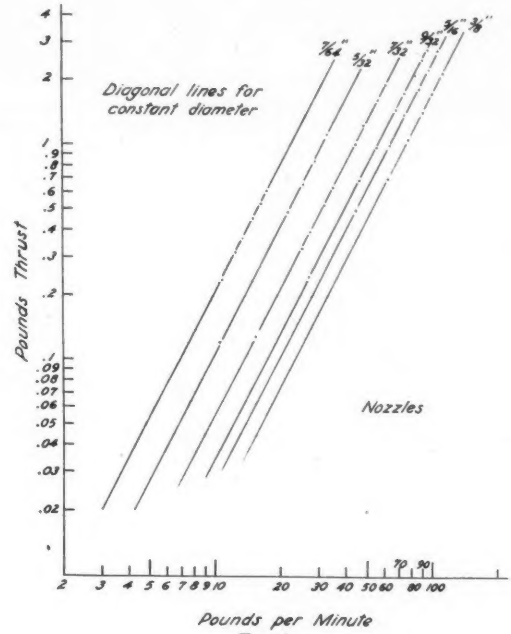


FIG. 4

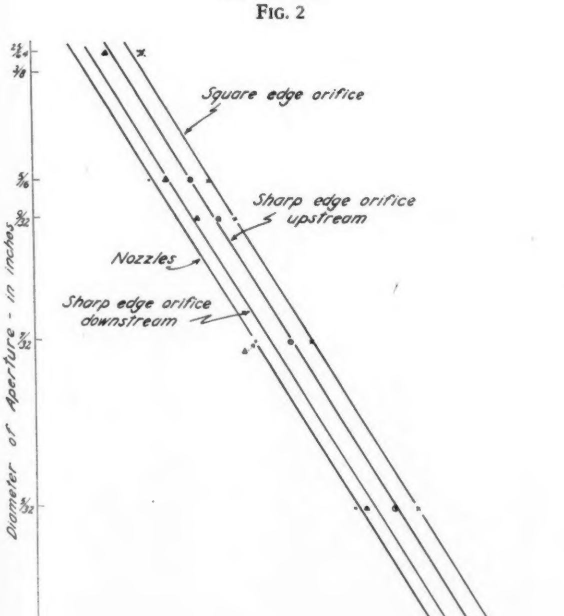


FIG. 3

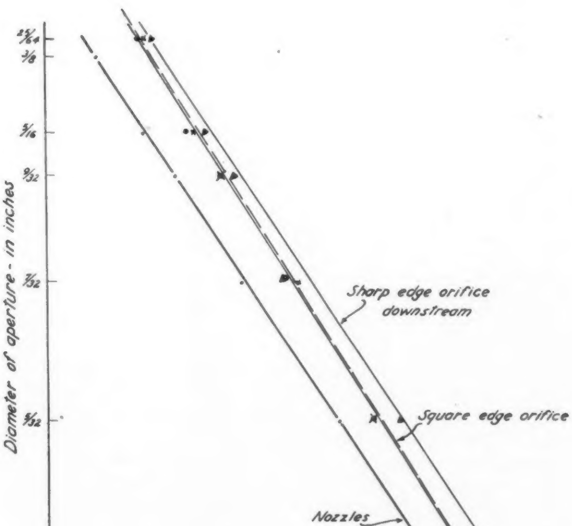


FIG. 5

TABLE 6. SPRINKLER JET TESTS

Size nozzle, in	Pressure head, ft	Thrust, lb	Q, lb/min
7/64	10.3	0.051	4.8
	19.4	0.112	7.7
	29.7	0.188	9.6
	26.8	0.233	11.0
	49.6	0.316	12.7
	57.2	0.364	13.8
	71.0	0.460	15.2
	82.6	0.544	16.7
	93.9	0.610	17.8
5/32	10.6	0.121	10.6
	15.4	0.212	13.7
	28.1	0.361	19.8
	34.6	0.489	22.0
	48.2	0.660	26.0
	59.0	0.845	29.4
	69.8	0.974	32.0
	78.7	1.123	33.5
	92.2	1.318	37.05
7/32	8.0	0.130	15.8
	15.3	0.336	25.4
	25.9	0.648	35.3
	39.4	1.016	45.0
	48.9	1.266	49.7
	61.8	1.657	56.8
	74.3	1.968	62.3
	82.9	2.206	66.1
	88.3	2.383	69.2
9/32	8.4	0.247	27.6
	17.6	0.689	46.6
	24.0	0.983	56.6
	34.8	1.497	69.3
	40.9	1.788	76.4
	49.5	2.179	84.7
	58.0	2.552	91.0
	64.7	2.854	98.0
5/16	7.1	0.210	28.8
	12.0	0.504	45.0
	21.3	1.032	64.9
	27.5	1.400	75.7
	36.7	1.886	88.0
	44.3	2.342	98.7
	52.2	2.801	109.6
3/8	7.4	0.306	42.6
	12.6	0.714	63.0
	17.3	1.096	79.5
	22.0	1.448	92.6
	26.1	1.796	101.3
	31.7	2.219	115.8
	38.2	2.765	129.4

TABLE 7. SPRINKLER JET TESTS

Size milled square-edge orifice plate, in	Pressure head, ft	Thrust, lb	Q. lb/min
7/64	18.9	.058	4.5
	35.3	.136	6.4
	45.2	.174	7.2
	59.4	.236	8.5
	71.6	.286	9.4
	88.9	.355	10.5
.5/32	12.2	.106	8.5
	18.5	.178	11.2
	27.5	.280	14.1
	42.3	.434	18.1
	58.5	.624	21.2
	71.3	.764	23.7
	85.4	.926	25.3
7/32	12.0	.176	14.9
	24.0	.402	22.8
	37.8	.671	29.2
	49.0	.910	34.3
	63.4	1.162	38.4
	74.0	1.358	42.1
	84.7	1.585	44.5
9/32	13.0	0.316	25.8
	20.1	0.552	34.3
	27.6	0.803	40.3
	43.5	1.292	52.2
	51.8	1.591	56.9
	61.3	1.886	62.8
	73.8	2.218	69.7
	82.8	2.528	73.4
5/16	11.8	0.334	29.1
	21.4	0.720	42.5
	31.3	1.076	52.7
	44.9	1.594	64.3
	55.6	1.934	73.0
	66.9	2.434	80.0
	72.4	2.688	82.7
25/64	12.7	0.584	46.4
	18.0	0.902	57.1
	22.1	1.154	66.1
	28.3	1.524	76.1
	39.4	2.136	90.7
	43.7	2.424	95.4
	48.4	2.690	103.2

of the head thrust equation. The skeleton of the steps taken is tabulated hereafter. Table 3 gives a summary of the slopes of the thrust-pounds per minute curves and the corresponding values of b on those curves for the various types and sizes of aperture tested.

The values of b for the several aperture types plotted against diameter on full log paper approximately define separate straight lines for each type aperture (Fig. 5). These curves represent the relationship of the values of b in Table 3 and diameter of aperture for the four test types. Table 4 presents the pertinent data obtained from these curves.

TABLE 4

Data from Fig. 5	Nozzles	Square-edge orifice	Sharp-edge orifice upstream	Sharp-edge orifice downstream
Slope (m)	–0.502012	–0.527522	–0.546114	–0.516683
Value of b	0.005417655	0.00536877	0.00463976	0.00617142

With the data in Tables 3 and 4 available, it is possible to derive equations in the general form $y = x^m b$ in terms of

TABLE 8. SPRINKLER JET TESTS

Size milled sharp-edge orifice plate (upstream), in	Head, ft	Net head, ft	Thrust, lb	Q, lb/min
7/64	16.8	13.0	0.076	3.8
	18.0	14.2	0.091	4.0
	33.0	29.2	0.162	5.7
	35.4	31.6	0.179	6.0
	47.0	43.2	0.252	6.7
	52.3	48.5	0.277	7.1
	58.8	55.0	0.312	7.8
	69.8	66.0	0.362	8.4
	77.3	73.5	0.403	8.6
	82.7	78.9	0.433	9.2
	89.4	85.6	0.465	9.6
5/32	12.7	8.9	0.122	8.5
	13.2	9.4	0.120	8.7
	24.1	20.3	0.263	13.0
	33.1	29.3	0.378	15.5
	40.7	36.9	0.471	17.4
	51.6	47.8	0.610	19.8
	54.5	50.7	0.644	20.2
	68.0	64.2	0.816	24.0
	70.9	67.1	0.856	23.3
	80.1	76.3	0.964	24.8
	80.7	76.9	0.980	24.9
7/32	13.1	9.3	0.221	16.1
	13.4	9.6	0.226	16.5
	23.1	19.3	0.447	22.9
	26.0	22.2	0.506	24.8
	37.6	33.8	0.748	30.2
	37.9	34.1	0.768	30.2
	49.4	45.6	1.006	35.0
	50.7	46.9	1.008	35.7
	64.8	61.0	1.356	39.5
	67.2	63.4	1.395	41.2
	73.0	69.2	1.569	42.8
	78.8	75.0	1.659	44.7
	84.8	81.0	1.839	46.6
	90.1	86.3	1.938	47.8
9/32	13.3	11.5	0.361	24.8
	16.3	12.5	0.427	28.8
	24.2	20.4	0.749	35.7
	28.4	24.6	0.852	39.8
	37.5	33.7	1.176	46.2
	40.0	36.2	1.236	48.1
	50.4	46.6	1.580	55.7
	54.1	50.3	1.779	56.7
	65.2	61.4	2.131	62.4
	69.4	65.6	2.271	64.4
	80.2	76.4	2.662	67.6
	84.9	81.1	2.814	72.7
5/16	13.0	9.2	0.408	
	13.3	9.5	0.422	31.6
	22.2	18.4	0.816	44.2
	27.3	23.5	1.010	50.2
	37.2	33.4	1.420	58.7
	47.3	43.5	1.916	68.0
	54.7	50.9	2.180	73.1
	57.4	53.6	2.284	75.4
	68.3	64.5	2.774	81.3
	70.4	66.6	2.866	83.7
25/64	12.5	8.7	0.605	44.2
	12.6	8.8	0.598	44.0
	17.9	14.1	0.936	55.4
	18.8	15.0	0.976	56.1
	24.4	20.6	1.298	66.0
	27.9	24.1	1.332	72.0
	32.6	28.8	1.812	78.8
	35.0	31.2	1.926	82.1
	39.4	35.6	2.161	87.8
	44.0	40.2	2.456	93.2
	48.4	44.6	2.716	95.9
	51.2	47.4	2.870	100.9

thrust, pounds per minute, and diameter. These equations are given in Table 5.

TABLE 5

Type of aperture	Equation derived from tables and Figs. 4 and 5
Nozzles	$\text{Thrust} = \text{lb per min}^{1.94855} \times \dfrac{0.0000306045}{\text{diam}^{1.991985}}$
Square-edge orifices	$\text{Thrust} = \text{lb per min}^{1.96095} \times \dfrac{0.0000497365}{\text{diam}^{1.89565}}$
Sharp-edge orifices upstream	$\text{Thrust} = \text{lb per min}^{2.005176} \times \dfrac{0.000053334}{\text{diam}^{1.83113}}$
Sharp-edge orifices downstream	$\text{Thrust} = \text{lb per min}^{1.925754} \times \dfrac{0.0000528988}{\text{diam}^{1.93543}}$

Seven-place log tables were used in making computations for the preceding, and since the decimals were easily obtained, they are presented completely herewith not to indicate that degree of accuracy, which is improbable, but only as a matter of record.

TABLE 9. SPRINKLER JET TESTS

Size milled sharp-edge orifice plate (upstream), in	Head, ft	Net head, ft	Thrust, lb	Q, lb/min
7/64	13.3	9.5	0.058	4.3
	14.1	10.3	0.069	3.1
	26.1	22.3	0.138	6.1
	26.8	23.0	0.148	6.3
	37.2	33.4	0.216	7.5
	37.4	33.6	0.216	7.5
	49.4	45.6	0.298	8.6
	52.3	48.5	0.316	9.2
	63.0	59.2	0.375	10.0
	71.5	67.7	0.425	10.6
	80.2	76.4	0.484	11.3
	84.1	20.3	0.512	11.6
5/32	17.3	13.5	0.202	11.2
	19.2	15.4	0.198	11.9
	27.9	24.1	0.347	14.8
	31.3	27.5	0.385	15.7
	40.4	36.6	0.524	18.2
	46.4	42.6	0.602	20.2
	56.4	52.6	0.732	22.2
	63.2	59.4	0.828	23.3
	67.8	64.0	0.892	24.2
	75.4	71.6	0.989	25.7
	83.7	79.9	1.091	27.2
	88.6	84.8	1.121	27.7
7/32	14.4	10.6	0.320	22.0
	15.4	11.6	0.357	22.8
	30.0	26.2	0.742	34.8
	31.8	28.0	0.866	35.5
	42.4	38.6	1.074	41.9
	47.1	43.3	1.240	44.1
	61.2	57.4	1.640	50.5
	61.6	37.8	1.646	50.5
	70.1	66.3	1.894	54.5
	70.9	67.1	1.928	55.5
	80.5	76.7	2.178	58.4
	85.6	81.8	2.272	60.9
9/32	15.3	11.5	0.518	34.3
	17.4	13.6	0.648	37.2
	27.8	24.0	1.051	49.0
	32.5	28.7	1.244	53.9
	37.4	33.6	1.457	59.1
	44.5	40.7	1.751	64.2
	52.8	49.0	2.064	70.6
	53.7	49.9	2.078	71.1
	65.8	62.0	2.593	79.5
	67.7	63.9	2.689	79.9
5/16	9.0	5.2	0.274	29.1
	9.3	5.5	0.292	29.5
	19.6	15.8	0.882	49.6
	20.8	17.0	0.941	50.9
	27.7	23.9	1.220	60.4
	29.4	25.6	1.341	62.6
	36.6	32.8	1.693	70.3
	40.0	36.2	1.886	74.9
	48.1	44.3	2.252	81.5
	51.1	47.3	2.428	84.4
	57.4	53.6	2.736	90.0
	57.6	53.8	2.754	90.4
25/64	10.9	7.1	0.623	50.8
	12.0	8.2	0,688	53.5
	17.0	13.2	1.041	68.6
	19.1	15.3	1.288	63.6
	22.8	19.0	1.552	82.0
	25.6	21.8	1.764	87.1
	28.3	24.5	1.926	92.0
	34.4	30.6	2.388	103.8
	36.1	32.3	2.504	103.7
	38.4	34.6	2.714	109.2

There was a noticeable difference between the jets that issued from the nozzles as compared with the square-edge orifice plates and the sharp edge orifice plates upstream, particularly. The jet from the nozzles had a cloudy appearance starting from ⅛ in to 1 in away from the aperture. The two orifice plates mentioned supplied glasslike shafts of water as long as 12 or 15 ft away from the aperture. These jets were perfectly transparent in this initial distance and without distortion; so it was easy to imagine it a solid static shaft.

Tables 6, 7, 8, and 9 are supplied to provide the test data from which the preceding were derived. It is obvious that other equations may be derived by combining those given for identical aperture types.

In Tables 6, 7, 8, and 9 the first column, zero, was the negative correction in feet necessary to bring the recorded head in feet, Column 2, to net head at the aperture. Heads plotted were, of course, net, and equations correspond.

Dairy Production

(Continued from page 159)

minute radio programs. The use of grain and ensilage carts can save steps and reduce the length of time spent in barn work. Farmers who did not use feed carts were walking several times as far and using considerably more time than those who used them. And transferring the load from the farmer's feet to wheels saves most of the hard work involved in carrying the tons of silage and grain which even a small herd requires in a month.

The manner in which the work is organized and the methods which are used is the third factor in dairy barn efficiency. Development of a work routine and the location of the tools used in the routine to avoid unnecessary walking can materially reduce the amount of time and travel. One farmer scrapes the platform behind the cows on one trip and then sweeps it on the return trip. The tools are returned to their original location during later trips for other purposes. A carefully worked out routine in the milkhouse is also a timesaver. A convenient arrangement of equipment and storage racks and an adequate supply of hot water are essential.

The time and travel studies on these 17 farms verified what agricultural engineers have known for years, namely, that the most efficient dairy barn arrangement is a barn 34 to 38 ft wide, with two rows of stanchions, cows facing out, or a combination of two rows of stanchions and pens. This study also showed that approximately three-fifths of the time spent in dairy barn chores was for milking, caring for the milk, and in cleaning the stable and handling bedding; or saying it another way, three-fifths of the barn chore time is spent behind the cows. With the face-out plan, the work behind the cows is more easily organized for greatest labor efficiency.

The next step in the dairy barn chore study was to secure a series of before and after records, where time and travel studies could be made before the barn was rearranged and then after the remodeling was completed. This study was begun in 1945. By a fortunate circumstance five farms where the owners wished to remodel their dairy barns were located in a small area. Time and travel records have been obtained in each of the barns before remodeling was begun, and a remodeling plan has been prepared for each cooperating farmer. As rapidly as suggested changes are made, new records are being secured. Since these records are not complete, it is not possible at this time to list the results of a better barn arrangement on labor efficiency.

The measurements which the time and travel studies have provided, of the relative efficiencies of different barn arrangement, management, methods, and organization of work and equipment, have proved to be helpful in getting other farmers started in thinking through their own problems with respect to these factors.

RESEARCH NOTES

(A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.)

THE Third Industry-Research Conference sponsored by the Farm Equipment Institute, with the aid and cooperation of the USDA Divisions of Agricultural Engineering, and held at the Agricultural Research Center, Beltsville, Md., on March 3 to 5, 1947, attracted more than 60 representatives from 35 different manufacturers in the farm equipment industry, including the major units as well as many smaller short-line companies. The register also included the names of representatives of a number of state agricultural experiment stations, farmers' organizations, the farm press, and other groups, bringing the total attendance to about 100.

The Beltsville meeting was easily the most outstanding of the three conferences so far held in which the F.E.I. agricultural research committee has provided the leadership. It was indicative of the growing interest in a cooperative approach by the industry and public service research agencies to mutual agricultural problems. The two previous meetings were held at the Illinois Agricultural Experiment Station, Urbana, in 1945, and at the Alabama Agricultural Experiment Station and USDA Tillage Machinery Laboratory, Auburn, in 1946.

Must Learn How to Use Research. The keynote of the conference was set in the opening statement by Secretary of Agriculture Clinton P. Anderson, who stressed the importance of the three groups—research workers, farm equipment, industry, and farmers—in solving the problems of agriculture. In the peacetime task that is ahead of us—the task of making the results of research bless instead of curse agriculture—each group can and must make its contribution, he pointed out.

"It is a fine thing," the Secretary said, "for research to develop a new weed killer like 2,4-D or a new insecticide like DDT, but it is a finer thing to learn how to use them. DDT and 2,4-D will both be valuable assets to the agriculture of this country in the years ahead. The problem is to use them to lift the load of the people who live in the country, and in this way make the research of value. In this process the scientists do the research and find the scientific uses of new materials or methods. The manufacture of farm machinery is a most important link between the laboratories and the farmer, for the manufacturer takes the results of research and develops the devices or machines that enable the farmer to use the scientist's findings. And in the final analysis, of course, it is the farmer who translates the laboratory findings into more and better food and fiber for a better standard of living for all of us."

Looking at the disturbed conditions in the world, the Secretary pointed to the importance of food as a force in lasting peace and the need for research to enable farmers to carry their part of the task. Later in the conference, at the noon luncheon meeting, the Hon. J. W. Flannagan of Virginia, one of the authors of the Flannagan-Hope Marketing-Research Act of 1946, elaborated on this idea: "The future of agriculture lies back there in the laboratory in research," he said. "In my judgment there never will be peace on earth as long as there are hungry people. The right kind of agricultural leadership can do more to cure the ills of the world than all the diplomats from Washington to Moscow."

"Research Has Done Mighty Things!" Responding to the Secretary of Agriculture, W. A. Roberts, president of the Farm Equipment Institute, expressed the interest of the industry in the research work now going on. "Our group, representing the farm equipment industry, is interested as taxpayers and as businessmen directly associated with agriculture in all research findings," he said. "That is why we have chosen to meet at the Agricultural Research Center. In the past I have heard it said that 'research is an attempt to find out what you are going to do when you can no longer do what you are doing now.' As a long-range proposition I should like to add that it ought also to attempt to do better what you're doing now.

"In the short space of the last 10 or 12 years research has done mighty things. Some of us live so closely to them, however, that we are inclined to accept these things nonchalantly. Let me point out, however, that for the first time in history our country and its allies have just fought and finished a great war without a serious threat of famine. How was this possible? It was the result, first, of a scientific approach to agriculture, and, second, because of the mechanization of farming.

"In the development of hybrid corn the research bill for the next 100 years has already been paid. It is very much in order, therefore, that those in research and industry who have contributed so much during the war should meet and go over the problems and developments of research that may affect farming in the peacetime years ahead, and in this way to help each other in the job of helping the farmer."

Following the Washington session of the conference two days were spent at the Agricultural Research Center, Beltsville, Md., in sessions packed with up-to-date information on the newest results of research having direct relationship to farm machinery and equipment. Dr. R. M. Salter, chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, described in some detail the wide scope of the work of the Bureau which touches every farm in the United States in one way or another.

The first day's sessions were devoted largely to the work in the plant and soils sciences. The work on plant growth regulators, particularly the use of the new chemical weed killers, was described by Dr. John W. Mitchell and L. G. Kephart. Dr. Mitchell told of the various reactions which different plants make to several growth-regulating chemicals. These are now being used for a number of different purposes, in addition to weed killing, such as the prevention of apple drop at harvest time. Mr. Kephart emphasized particularly the need for new spraying and dusting equipment for applying the new materials.

"For weed spraying, high pressures are not needed or wanted," Mr. Kephart said, "but high speed is a necessity. Reconverted orchard sprayers are not the answer. A sprayer with a 40 to 50-ft boom, operated at 50 to 60 lb pressure, using not more than 20 gal of liquid per acre, and with a ground speed of at least 6 miles an hour, calls for special design. There is also need for better equipment for spraying and dusting by airplane as well as for first-class methods of sterilizing the soil."

Another report by Dr. G. Steiner was on the nematode problem. These eelworms, mostly invisible to the naked eye, are in the soil wherever plants grow, literally millions of them, Dr. Steiner pointed out. They attack plants in many ways—roots, leaves, seeds, other parts, causing dwarfing, poor growth, decay, and other symptoms. Some recent promising results from soil fumigation with newly developed chemicals were described by the speaker. The use of these materials will, of course, require development of machines to apply them.

Sessions of the conference with the agricultural engineering group at the Agricultural Research Center, including most of the second day, were devoted to the research work at various points throughout the country in farm power and machinery, particularly with reference to the F.E.I. research outline, farm electrification, farm buildings and rural housing, and mechanical processing of farm products, with discussions by R. B. Gray, T. E. Hienton, Wallace Ashby and Geo. R. Boyd. The over-all program of the divisions was presented by A. W. Turner, assistant chief (BPISAE) in charge of agricultural engineering research, using a composite movie to show various developments.

One of the high lights of the entire program was the dinner meeting on Monday night at the Log Lodge on the Agricultural Research Center grounds, with Dr. W. V. Lambert, agricultural research administrator, headlining the program, followed by the chiefs or representatives of the other research agencies of the ARA.

* * * *

Sweet Potato Mechanization. On March 11, 12, and 13 three meetings were held in southern Louisiana on problems of sweet potato production and utilization, with emphasis on mechanization. The March 11 conference, at the USDA Southern Regional Research Laboratory in New Orleans, brought together members of the Laboratory staff and collaborators from the southern states agricultural experiment stations to discuss recent investigations and development in industrial utilization of sweet potatoes and related considerations of raw material quality and cost. On the following day the Louisiana State Sweet Potato Association meeting at Lafayette drew many of the same research workers.

A further conference at the Southern Regional Research Laboratory, New Orleans, on March 13, dealt primarily with problems of sweet potato production for industrial utilization and especially with development of labor-saving machinery and equipment for crop production. It was recognized that low-cost volume production of sweet potatoes has lagged behind progress in development of industrial processing and outlets for the products.

The process of making starch from sweet potatoes has been fairly well worked out and the importance of sweet potatoes for stock feed is becoming more thoroughly established. Dehydration for feed, production of feed yeast and development of other coproducts or byproducts are under intensive investigation by scientists in federal, state, and industrial laboratories. Extended exploitation of industrial outlets for sweet potatoes rests, however, on production of the crop at a cost low enough to allow profit from the processing enterprise as well as a fair return to the grower. Mechanization of the crop is indispensable to low-cost production. Transplanters and harvesting equipment are particularly needed.

Representatives of farm equipment manufacturers were invited to the second New Orleans conference, and the Division of Farm Power and Machinery (BPISAE) was represented at the three meetings by J. K. Park of Clemson, S. C., in charge of sweet potato production and harvesting machinery.

NEWS SECTION

A.S.A.E. Meetings Calendar

April 17 to 19 — Missouri Section, Hotel Muehlebach, Kansas City, Mo.

May 16 and 17 — Virginia Section, Hotel Roanoke, Roanoke, Virginia.

June 23 to 25—ANNUAL MEETING, Benjamin Franklin Hotel, Philadelphia.

October 23 and 24 — Pacific Northwest Section, Davenport Hotel, Spokane, Wash.

December 15 to 17—FALL MEETING, Stevens Hotel, Chicago.

Dairy Housing Conference in July

A DAIRY Housing Conference sponsored cooperatively by the Farm Structures Division of the American Society of Agricultural Engineers, and the University of Wisconsin has been scheduled to be held at Madison, July 22 to 24.

General subjects scheduled for major consideration include sanitary dairy production, research in dairy housing, tools and methods for dairy housing construction, and functional requirements. A tour of the University of Wisconsin Dairy Barn Research Project and to several dairy farms in the area is scheduled for one afternoon. The program indicates a coordinated consideration of production and marketing objectives, engineering design and materials, and operating costs. Speakers are to be announced in the near future.

Local conditions will determine whether the Conference will be held at the University or at a downtown hotel. Further information will be furnished in ample time to permit advance registration of persons interested.

Dewey Long to Colombia

J. DEWEY LONG, president of the American Society of Agricultural Engineers in 1945-46, recently resigned his position as director of education and market research for the Douglas Fir Plywood Association, to become consulting agricultural engineer to the government of the Republic of Colombia.

In this work, which is planned to require about a year, he is to advise the government on a program of agricultural engineering development as a part of its postwar plan for improvement and modernization of its agriculture.

Mr. Long is proceeding to his new headquarters at Bogota, Colombia, via Washington, D. C., where he is to do some preliminary orientation work with the Office of Foreign Agricultural Relations of the U. S. Department of Agriculture.

Virginia Section Meets in May

THE Virginia Section of the American Society of Agricultural Engineers will hold its spring meeting on May 16 and 17 at the Hotel Roanoke, Virginia. Members and friends of the Society are cordially invited to attend. A copy of the program will be mailed to all members of the Virginia Section, as soon as final details are completed. Anyone who would like to see a copy of the program may obtain one by writing directly to U. F. Earp, Section Secretary, Virginia Polytechnic Institute, Blacksburg.

Airplane view of the 1946 National Plow Terrace Building Contest in Mills County, Iowa

A.S.A.E. Rules for Terrace-Building Contest

A REPORT of the second annual National Plow Terrace Building Contest held in Mills County, Iowa, September 10 and 11, 1946, has recently been published by the World-Herald of Omaha, Neb., one of the sponsors. Other sponsors of the contest included the Mills County (Iowa) Soil Conservation District, the agricultural department of the Omaha Chamber of Commerce, and the Omaha Farm Equipment Club. The rules and regulations used in this contest followed closely the tentative recommendations for such contests drafted by a special committee of the American Society of Agricultural Engineers early in 1946.

Twenty-eight entries competed in the moldboard class and eight in the open class. An audience of 20,000 attended the event, which also included educational exhibits, talks on conservation, and miscellaneous minor contests.

Several A.S.A.E. members officiated in the contest. Ralph C. Hay, associate professor of agricultural engineering extension, University of Illinois, served as chairman of judges. Other judges were Wm. E. Meek, agricultural engineer, Delta Branch Station, Mississippi Agricultural Experiment Station; C. R. Johnson, assistant extension agricultural engineer, Iowa State College, and C. W. Smith, professor of agricultural engineering, University of Nebraska.

With development of terrace building contests as agricultural field events, A.S.A.E. members concerned recognized the desirability of such contests being held in some uniform manner calculated to demonstrate and emphasize sound conservation procedures. A committee appointed to study the problem developed a set of rules and regulations which were approved by the Council of the Society and published in March,

This good-natured looking group comprises the Ontario Student Branch of the American Society of Agricultural Engineers at Ontario Agricultural College at Guelph, Province of Ontario, Canada. In the second row, left to right, is Jack Clark, first-year representative of the Branch; B. I. Graham, treasurer; C. G. E. Downing, honorary president of the Branch and head of the agricultural engineering department of O.A.C.; Robert C. Warren, president; Thos. R. C. Rokeby, scribe, and John Barrie, secretary. The names of others in the picture were not furnished.

1946, as "A.S.A.E. Tentative Recommendations." From observation of their use during the past summer in county, state, and national contests, the Committee feels that they are generally satisfactory and has recommended their formal adoption, with a few minor changes, as an "A.S.A.E. Recommended Practice."

Members of the A.S.A.E. committee, known as the Committee on Rules for Terrace Building Contests, were T. B. Chambers (chairman), chief, division of engineering, U. S. Soil Conservation Service; Wm. E. Meek; J. T. Copeland, extension agricultural engineer, Mississippi State College; D. A. Milligan, director of service, Harry Ferguson, Inc.; R. C. Hay; L. G. Samsel, educational division, J. I. Case Co., and R. W. Jones, conservationist, U. S. Soil Conservation Service.

K. J. T. Ekblaw, Past-President A.S.A.E., Has Passed On

KARL J. T. EKBLAW passed away March 20, 1947, at Billings General Hospital, Chicago, Ill., following a hospitalization of a number of months.

A native of Illinois, Mr. Ekblaw was born July 14, 1884, and following graduation from high school he entered the University of Illinois, where he earned the bachelor of science degree in mechanical engineering in 1909, and the master of science degree in architecture at the same school in 1913. He ldter attended the Sheffield Scientific School at Yale University where he was awarded the professional degree of mechanical engineer.

Starting his career in the agricultural engineering field immediately after graduation, he continued on the staff of the division of farm mechanics (now department of agricultural engineering) at the University of Illinois from 1909 to 1916. From there he went to Kansas State College to organize a department and serve as professor of rural engineering until 1919. Then for two years he served as engineering editor of a number of farm papers and did some special work on farm machinery for the International Harvester Company. He also served for a time as farm buildings architect for the U. S. Department of Agriculture.

From 1921 to 1925 he was employed as an agricultural engineer by the Portland Cement Association, and continued as consulting agricultural engineer of the organization from 1925 to 1927. Next he became agricultural engineer and vice-president of the Frank B. White Company, an advertising agency. This led to his later connection as agricultural engineer for the American Zinc Institute, in which position he continued until his retirement in 1945.

Karl Ekblaw became a member of the American Society of Agricultural Engineers in 1920, served on a variety of committees, as a member of the Council, as chairman of the Farm Structures Division, and as a vice-president. He served as president of the Society during the year 1939-40. He was author of two early texts and references on "Farm Structures" and "Farm Concrete."

Mr. Ekblaw is survived by his widow.

KARL J. T. EKBLAW
1884 - 1947

Chemurgists Hear Agricultural Engineers

ALL technical branches of agricultural engineering in their relation to ways and means of chemurgic progress, were brought to attention in the Twelfth Annual Chemurgic Conference at Oklahoma City, March 26 to 29.

A.S.A.E. members on the conference program included, in addition to Wheeler McMillen, president of National Farm Chemurgic Council, A. S. A. E. Past-Presidents L. F. Livingston and Arnold P. Yerkes and several others.

Additional A.S.A.E. members seen about the conference and contributing to the discussion included H. M. Bainer, E. W. Hamilton, H. E. Everett, V. S. Peterson, J. E. Stahl, and Dawson G. Womeldorff.

L. F. Livingston was the featured speaker at the opening "State Dinner", in which the governor, members of the legislature and other Oklahoma state officials were brought up to date on the national and local significance of farm chemurgy.

Paul M. Mulliken, secretary, National Retail Farm Equipment Association, pictured for the conference some individual and national problems of "Tooling Up" for postwar farm and chemurgic production.

In a session devoted to the relationship between the petroleum industry and agriculture, George Krieger, agricultural engineer, Ethyl Corporation, summarized "The Agricultural Program of the Petroleum Industry." Mr. Krieger is chairman of the agricultural committee of the American Petroleum Institute.

Farm power and machinery relationships with chemurgy were further clarified by Mr. Yerkes, in charge of farm practice research for the International Harvester Co., in the closing roundtable of the conference. At the same session, Paul N. Doll, of the Missouri Limestone Producers Association and the Missouri Farm Chemurgic Council, reported on chemurgic industries in that state.

Program representation of farm structures interest in chemurgy was provided by Donald M. Crooks, Midwestern representative of the Douglas Fir Plywood Association, in a talk on "Plywood as Related to Farm Chemurgy."

Rural electric and soil and water branches of agricultural engineering, while not directly included in the program, were acknowledged along with agricultural engineering in general, by various speakers from other fields, as important means to tangible progress in chemurgy.

Personals of A.S.A.E. Members

J. Reid Bishop, until recently associate engineer appraiser of the Federal Land Bank of Saint Louis, has recently entered into partnership with his brother at LeRoy, Ill., to engage in the hatchery and feed business, including fertilizer, hybrid seed corn, farm buildings, farm machinery, and general agricultural engineering service.

Gustav H. Bliesner, in addition to his work as assistant professor of physical sciences at Farragut College and Technical Institute, Farragut, Ida., is also serving as a member of the college athletic board and as national expansion secretary of the Alpha Kappa Lambda fraternity.

Joseph S. Buchanan, Jr., more recently soil conservationist of the U. S. Soil Conservation Service at Canton, Miss., is now drainage engineer at the same SCS headquarters, and his new work covers all drainage enginering of the SCS and the state of Mississippi in the counties of Attala, Choctaw, Montgomery, Carrol, Webster, Madison, Leake, Scott, and Rankin.

Frank J. Capouch, director of field service for the Bowman Dairy Company, Chicago, was recently elected president of the Associated Illinois Milk Sanitarians, the professional society of milk sanitarians in the state of Illinois.

Kermit R. Cline, who served as an officer in the Coast Artillery of the U. S. Army during the war, is now employed as agricultural engineer in the Applications and Loans Division of the Rural Electrification Administration, USDA, and is engaged in promoting the use of electric power in agriculture.

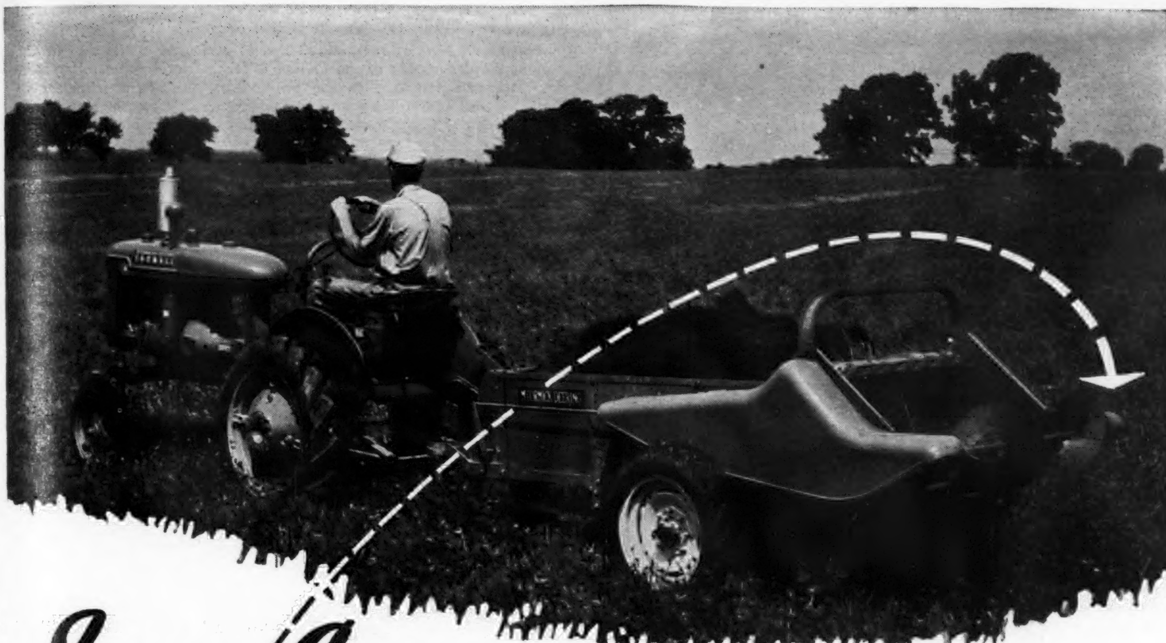
Paul N. Doll has resigned as agricultural engineer, Missouri State Department of Resources and Development, to become manager of the Missourl Limestone Producers' Association with headquarters at Jefferson City, Mo.

Erwin G. Dueringer, until recently assistant manager, Do-Well Agricultural Service, has launched his own organization called the Dueringer Farm Land Service, at 338 North Hickory St., Champaign, Ill. He will engage in the general business of farm land management.

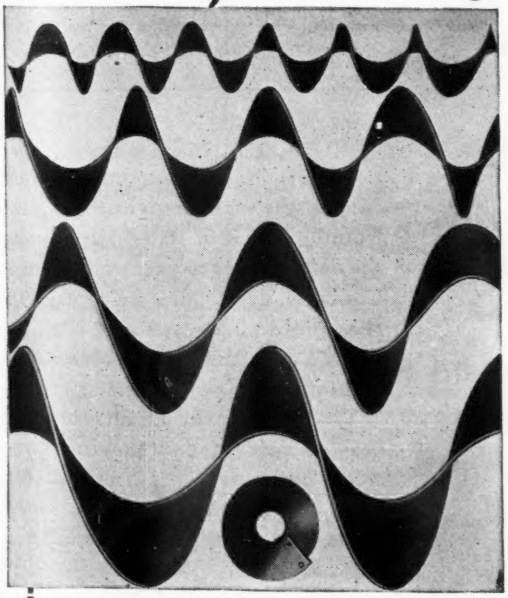
Emil W. Eliason, who served as an officer in the U. S. Naval Reserves during the war, is now employed as farm store manager of Sears, Roebuck and Company, at Appleton, Wis.

Henry Giese, professor of agricultural engineering, Iowa State College, at the invitation of Major General Philip B. Fleming, administrator, Federal Works Agency, will serve as a member of the Committee on Fire Prevention Education of The President's Conference on Fire Prevention. The Conference will be held in the Interdepartmental Auditorium, Washington, D. C., May 6, 7, and 8, 1947, and will be limited to 2,000 people who will attend by invitation.

(Continued on page 168)



Screw Conveyor from LINK-BELT Serves Many Purposes!



Link-Belt Company originated and is the largest producer of continuous rolled "Helicoid" conveyor. Standard sizes range from 2½" to 18" outside diameter. For conveying, elevating, mixing, blending, of loose, granular material use "Helicoid" conveyor and Sectional Flight Conveyor by LINK-BELT.

Increased use of screw conveyor on modern farm equipment is a natural development, as its special advantages become recognized. Application of screw conveyor to manure spreaders of recent design is an example of the resourcefulness of engineers, and illustrates the adaptability of this type of conveyor to various purposes, besides conveying bulk material such as grain, in the usual manner.

Through unmatched experience and production facilities, Link-Belt Company is especially well equipped to supply screw conveyor and flighting, either continuous rolled "Helicoid" or sectional, to the agricultural implement industry. We welcome inquiries and will gladly cooperate with your designers in making effective use of this efficient form of conveyor.

LINK-BELT COMPANY

Chicago 8, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities. 10,039

LINK-BELT SCREW CONVEYOR

COLLARS · COUPLINGS · HANGERS · TROUGHS · BOX ENDS · FLANGES · THRUSTS · DRIVES

Personals of A.S.A.E. Members

(Continued from page 166)

Walter W. Hinz has resigned as a member of the agricultural engineering staff of the State College of Washington to accept a position as associate engineer with the Bureau of Reclamation, U. S. Department of the Interior, in the Columbia River Basin. He will be located at Ephrata, Wash.

Melville M. Johns recently resigned as extension agricultural engineer, University of Tennessee, to accept appointment as district manager of the Southern States Cooperative, Inc., with headquarters at Culpeper, Va.

Robert H. Joyce on release from the armed services began operating his ranch and irrigated farm at Ulysses, Kan. He is developing a deep-well irrigation system to supplement natural moisture.

Aldert Molenarr has resigned as assistant irrigation engineer, division of irrigation, University of California, to return to the State College of Washington where he has accepted appointment as associate professor and assistant agricultural engineer in the agricultural experiment station. His principal assignment will be the development of a teaching and research program in irrigation.

Weldon O. Murphy recently resigned his position with the service division of Harry Ferguson, Inc., to join the J. I. Case Company in the capacity of factory sales representative for the tractor works of the company at Racine, Wis.

John E. Nicholas, professor of agricultural engineering at the Pennsylvania State College, talked on the importance of farm and home freezers in the frozen food locker plant before the Pennsylvania Association of Frozen Food Locker Operators at Harrisburg on March 22, and on a similar subject before the Georgia Frozen Food Locker Plant Association at its conference at Athens April 1-3.

Gordon W. Olsen, until recently associated with the Palmer Terracing Company, has accepted appointment as assistant tractor testing engineer in the tractor testing laboratory at the University of Nebraska.

Elwood F. Olver recently resigned as instructor in agricultural engineering at Pennsylvania State College to become a rural representative for the Pennsylvania Power and Light Co. at Williamsport, Pa.

C. V. Phagan has resigned as extension agricultural engineer at Clemson Agricultural College to accept a similar position at Oklahoma A. & M. College, Stillwater. Before going to South Carolina in 1936 he served a period of seven years as assistant extension agricultural engineer in the state to which he is now returning.

Russell R. Poynor, engineer on special agricultural problems in the engineering department of the Canton Works of International Harvester Co., has been promoted to the position of agricultural engineer in charge of soil conservation engineering in the Company's farm implement division at Chicago. Mr. Poynor is a graduate in both agricultural and civil engineering at the University of Wisconsin, and also has a degree in soil mechanics from Purdue University. In addition to having served on the agricultural engineering staffs of three land-grant colleges, he was also associated for several years with the U. S. Soil Conservation Service.

James B. Putman, who served in the Corp of Engineers of the U. S. Army during the war, attaining the rank of captain, and who saw foreign service in New Guinea, the Philippines, and Japan, and more recently employed as an assistant regional engineer of the Farmers' Home Administration of the USDA, is this month entering the irrigation well-drilling business in connection with which they will handle and install irrigation pumps and render other irrigation service to farmers.

John W. Rockey, who served in the U. S. Army Air Forces during the war, attaining the rank of lieutenant colonel, has returned to his work as agricultural engineer with the Farm Buildings and Rural Housing Division (BPISAE), U. S. Department of Agriculture, and is stationed at the Agricultural Research Center at Beltsville, Md.

Glenn E. Saba has recently accepted employment as agricultural sales engineer with the Baldwin-Duckworth Division of Chain Belt Company, Springfield, Mass. His work will include contacting the engineering departments of farm machinery manufacturers relative to their power transmission problems, especially those dealing with roller chain applications.

Howard S. Smith, until recently manager of the rural electrical equipment division of Trumbull Electric Mfg. Co., is now associated with a company specializing in electric farm equipment, the Smith Gates Corp., at Plainville, Conn. This company builds immersion water heaters and temperature control mechanisms for dairy and poultry production operations, also electric brooders of advanced design and other items of electric farm equipment.

Darius E. Washburn is now manager of the farm electrical department of United Cooperatives, Inc., with headquarters at Alliance, Ohio. He resigned recently as agricultural engineer, division of electrical development, Tennessee Valley Authority.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

T. P. Balakrishnan, engineer, department of agricultural machinery, Government of India, New Delhi, India. (Mail) 189 Rouse Ave.

C. A. Bradford, agricultural engineer, Public Service Co. of Oklahoma, P. O. Box 201, Tulsa, Okla.

Allan H. Burman, instructor in agricultural engineering, University of Minnesota, St. Paul, Minn. (Mail) 1737 Eustis St.

David W. Chandler, assistant county agent, Marion, Ark.

Joseph P. Collopy, superintendent, Gila Project, Bureau of Reclamation, USDI. (Mail) 1505 Sixth Ave., Yuma, Ariz.

Tom E. Corley, graduate assistant in agricultural engineering, Alabama Polytechnic Institute, Auburn, Ala.

John A. Danielson, farm service representative, Puget Sound Power and Light Co. (Mail) 286 Fourth St., Bremerton, Wash.

William Duke III, agricultural engineer, Agricultural Associates, Inc., Ardsley, N. Y. (Mail) 4 Park Ave.

W. C. Dutton, director, field agricultural chemicals research, The Dow Chemical Co. (Mail) 523 Bailey St. East Lansing, Mich.

Lawrence M. Eidsmore, junior agricultural engineer, Agricultural Associates, Inc. (Mail) 51 Grandview Ave., Dobbs Ferry, N. Y.

J. K. Gaunt, engineering superintendent, H. V. McKay Massey-Harris Pty., Ltd., Sunshine, Victoria, Australia.

George T. Gibson, assistant in agricultural engineering, Michigan State College, East Lansing, Mich.

R. D. Grant, district agriculturist for Soldier's Settlement and Veterans Law Act. (Mail) 2936 West 21 Ave., Vancouver, B. C., Canada.

Joseph B. Hammon, regional agriculturalist, Bureau of Reclamation, USDI. (Mail) 2015 P St., Sacramento, Calif.

G. W. Howard, staff engineer, The Beet Sugar Development Foundation, Box 531, Fort Collins, Colo.

Fred W. Kesler, district sales manager, Rilco Laminated Products, Inc. (Mail) 511 W. 13th St., Sterling, Ill.

M. H. Khan, student in agricultural engineering, University of Wisconsin, Madison, Wis.

E. W. King, designing engineer, H. V. McKay Massey-Harris Pty., Ltd., Sunshine, Victoria, Australia.

Robert E. Kyle, junior engineer, The Oliver Corporation, South Bend, Inc. (Mail) 3218 S. Main St.

A. Latif, foreign liaison representative (India), Soil Conservation Service, USDA. (Mail) P. O. Box 426 A, Chandler, Ariz.

F. E. Lichte, cotton gin specialist, agricultural extension service, A. and M. College of Texas. (Mail) 914 S. College Ave., Bryan, Tex.

Allan W. McCulloch, head, irrigation section, Soil Conservation Service, USDA. (Mail) 4555 N. E. 82nd, Portland 13, Ore.

Herbert F. Miller, Jr., graduate fellow in agricultural engineering, A. and M. College of Texas, College Station, Tex. (Mail) Box 570.

Fred C. Sackrider, graduate student in agricultural engineering, Michigan State College. (Mail) R. R. No. 1, Parma, Mich.

Carl W. Saldeen, experiment engineer, The Oliver Corp., Battle Creek, Mich. (Mail) 45 Yale St.

G. O. Schwab, instructor and graduate student in agricultural engineering, Iowa State College, Ames, Iowa.

Ray Sullivan, salesman, Starline, Inc., Harvard, Ill. (Mail) 206 E. Diggins St.

Stanley C. Swanson, engineer, Gates Rubber Co., 999 So. Broadway, Denver 17, Colo.

A. A. Thompson, assistant agricultural engineer, Opekasit Farm Management, Lebanon, Ohio. (Mail) 228 S. Mechanic St.

Louis J. Toupence, managing editor, lubrication charts, The Chek-Chart Corp., 624 S. Michigan Ave., Chicago 5, Ill.

M. O. Whithed, senior rural representative, Atlantic City Electric Co. (Mail) Pleasantville, N. J.

TRANSFER OF MEMBERSHIP GRADE

Chas. A. Bennett, principal agricultural engineer, Divisions of Agricultural Engineering, (BPISAE), USDA. (Mail) P. O. Box 426, Leland, Miss. (Member to Fellow)

Ralph J. Bugbee, director, farm department, Central Vermont Public Service Corp., 121 West St., Rutland, Vt. (Associate to Member)

Spencer H. Daines, acting head, agricultural engineering department, Utah State Agricultural College, Logan, Utah. (Junior Member to Member)

(Continued on page 172)

Applicants for Membership

(Continued from page 170)

Bertis L. Embry, assistant professor of agricultural engineering, Utah State Agricultural College, Logan, Utah. (Mail) RFD (North Logan) (Junior Member to Member)

Orville C. Hansen, soil conservationist, Soil Conservation Service, USDA. (Mail) 3509 C. Street, Lincoln, Nebr. (Junior Member to Member)

Donald L. Hitch, extension specialist in irrigation, University of Arizona, Tucson, Ariz. (Junior Member to Member)

Houston N. Irvine, assistant chief engineer, J. I. Case Co. (Mail) 716 N. 3rd St., Burlington, Iowa. (Junior Member to Member)

Albert F. Keegan, draftsman and designer, T. Ewing Shelton, Architect, First National Bank Bldg., Fayetteville, Ark. (Associate to Member)

Alfred D. Longhouse, professor and head, agricultural engineering department, West Virginia University, Morgantown, W. Va. (Mail) Oglebay Hall. (Associate to Member)

E. L. Ocock, farmer, Union, Ill. (Junior Member to Member)

Albert E. Powell, office engineer in design of farm buildings, Structural Clay Products Institute, 120½ Welch Ave., Ames, Iowa. (Junior Member to Member)

J. W. Wagner, president, Turner Mfg. Co., Box 987, Statesvelle, N. C. (Associate to Member)

Orville W. Zastrow, assistant engineer, technical standards division, Rural Electrification Administration, USDA. (Mail) 2821-28th St., N. W., Washington 8, D. C. (Junior Member to Member)

New Literature

THE FREEZING PRESERVATION OF FOODS, by Donald K. Tressler and Clifford F. Evers. Cloth, XVIII + 932 pages, 5½ x 8 inches. Illustrated and indexed. Avi Publishing Co., New York, $10.00.

This is a second edition of a work originally published in 1943, revised and enlarged to cover more recent advances in the technology of freezing foods. It should prove a valuable reference for those experienced in food refrigeration as well as many with new interests in this field. It deals largely with use requirements, opportunities, and methods from the operator's viewpoint as distinguished from engineering ways and means of refrigeration design to meet various requirements. Subjects covered include food freezing — present importance and potentialities; the principles of refrigeration; cold storages, sharp freezers and sharp freezing; quick freezing and the quick freezing systems; freezing cabinets and walk-in freezers; frozen food locker plants; packaging materials and problems; changes occurring during the preparation, freezing, cold storage, and thawing of foods; adaptability of vegetables and vegetable varieties to freezing; the freezing of vegetables; adaptability of fruits to freezing; the preparation for freezing and freezing preservation of fruits; the manufacture and freezing of fruit juices; preparation of food for home freezing; the preparation and freezing of meat; the preparation and freezing of poultry; the preparation and freezing of fish; the preparation and freezing of shellfish; the freezing of dairy products; the preparation of precooked frozen foods; the storage, transportation and marketing of frozen foods; the nutritive value of frozen foods; the cooking and serving of frozen foods; the microbiology of frozen foods — plant sanitation; the importance of quality control and standards in the frozen foods industries.

Appendixes give specific data on standards for grades of frozen fruits and vegetables; objective tests for quality of vegetables; determination of maggot infestation of blueberries; objective tests for the quality of meat, poultry, and fish; bacterial examination of products; the determination of the rate of moisture transmission through papers and boards; standards for rating home freezers; Illinois rules and regulations governing the licensing and operation of frozen food lockers.

THE HOME FREEZER HANDBOOK, by Gerald J. Stout. Cloth, XIII+ 345 pages, 5½ x 8½ inches. Illustrated and indexed. D. Van Nostrand Co. $3.95.

A practical guide to present and prospective users on choice and building of freezers and practice in freezing and storage. Information is grouped into sections on general considerations, buying a factory built freezer, building a home freezer, care of the home freezer, building combination storage and freezer, and preserving foods by the freezing method.

DISINFECTION OF MATTRESSES, by E. H. Gibbons, W. D. Harris, and P. J. A. Zeller (Paper, 26 pages, 6x9 inches, illustrated. Bulletin No. 87, 1945, Texas Engineering Experiment Station, A. & M. College of Texas.) A report of research on chemical and heating methods of disinfection with summary and conclusions recommending the most desirable procedure. The study was made at the request of the state department of health.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: MAY — O-503. JUNE — O-506. AUGUST — O-510. SEPTEMBER — O-516, 520, 521. NOVEMBER — O-523. DECEMBER—O-526, 527, 531, 532. JANUARY—O-535. FEBRUARY — O-540, 541, 542. MARCH — O-543, 544, 546, 547, 548.

POSITIONS WANTED: FEBRUARY—W-207. APRIL—W-232, 237, 276, 292. MAY—W-309, 312. JUNE—W-316, 320, 322. SEPTEMBER—W-337. NOVEMBER — W-358. DECEMBER — W-361, 367. FEBRUARY—W-371, 373, 374. MARCH—W-375, 377, 378, 379, 380, 382.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER (instructor) for teaching and research in farm structures in a north central state university. BS deg in agricultural engineering, or equivalent. Experience in college teaching or research, or with a commercial organization desirable. Opportunities for advancement comparable to those in college work generally. Age, 25 - 30. Salary, about $3600, depending on qualifications. O-549

AGRICULTURAL ENGINEER for extension work in electrification in corn belt state. BS deg in agricultural engineering or equivalent with two to five years experience in rural electrification work. Usual personal qualifications for extension work. Good opportunity for advancement. Age, 25 - 35. Salary $3400 - $4200. O-550

AGRICULTURAL ENGINEERS (2) (assistant professor) for teaching machinery, irrigation, and structures, with some field work and research, in a university in western Canada. MS deg in agricultural engineering, or equivalent, with two years teaching experience. Must be alert, energetic, and resourceful. Opportunity for advancement normal to teaching institutions. Age, under 32. Salary $3000. O-551

FARM MANAGER, for highly developed fruit and nut farm of 500 acres in California. BS deg in agricultural engineering, preferably with some experience in fruit farming as practiced in California, especially as to dried peaches, prunes and walnuts. Must know irrigation, pruning, and spray programs. Desire Protestant, church worker, in good health and with no bad habits. Good opportunity for qualified engineer and business man. Farm well located in progressive community, near a state college, and includes a Class II airport. Owner is graduate engineer and member of A.S.A.E. and other engineering societies. Prefer man about 35. Salary open. O-552

AGRICLTURAL ENGINEER, for research in farm structures and machinery, with particular reference to potato production, in a state agricultural experiment station in New England. BS or MS deg in agricultural engineering preferably from a school in one of the northern states. Prefer man with some experience in storage structures and in equipment for handling farm products, capable of coordinating research in harvesting, handling, storing, and packaging potatoes. Good opportunity for advancement. Age, under 40. Salary $3500 - $4500, depending on experience and training. O-553

AGRICULTURAL ENGINEER, for research in farm electrification, with immediate attention to curing of tobacco in the Southeast. BS deg in agricultural engineering, or in electrical engineering if combined with farm experience. Experience desirable but not essential for man with initiative and interest in research in rural electric field. Opportunities as provided by U. S. Civil Service. Age, 28 - 35. Salary, $2644.80-$4149.60. O-554

AGRICULTURAL ENGINEER for teaching power and machinery in a north central state university. Work will include assisting in teaching of advanced courses, and teaching service courses in dairy and horticultural machinery. BS and MS deg in agricultural engineering desired. Some teaching experience or evident aptitude for teaching. Prefer a neat, clean cut, cooperative man who is a good mixer, has a sense of humor, and is interested in a church. Excellent opportunity for qualified man. Age 25 - 35. Salary $3000 - $3400. O-555

AGRICULTURAL ENGINEER for research in rural electrification, particularly refrigeration, in a north central state university. BS and MS deg in agricultural engineering or equivalent desired. Some previous experience in commercial teaching, or research work in rural electrification field. Prefer a neat, cooperative, aggressive man with sense of humor and an interest in church and community enterprises. Good opportunity for qualified man. Age, 25 - 30. Salary $3200 - $3800. O-556

ASSISTANT INSTRUCTORS (3), one each in fields of power and machinery, farm structures, and water control in a north central state university. BS deg in agricultural engineering. Prefer men with some experience in students and with church affiliation. Opportunity to complete requirements for an MS deg in agricultural engineering in 6 quarters. Age, 21 or over. Salary $1200 for 3 quarters. O-557

(*Continued on page 176*)

PROFESSIONAL DIRECTORY

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 174)

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires research or planning work in water utilization duty of water, and estimating water supplies and crop yields. Deg of Petroleum Engineer, Colorado School of Mines, 1927, and graduate of Army Engineers School, 1939. Experience in soil and water field in U. S. Civil Service, 13 years, and miscellaneous other work in civil and mining engineering. Particularly interested in return to civil service, from which furloughed by reduction of force order in Bureau of Agricultural Economics. No physical defects, available on short notice. Married. Age, 42. Salary $5000. W-383

AGRICULTURAL ENGINEER desires work in private company in soil and water, farm structures, or sales field. BS deg in arts and science 1944, and in agricultural engineering, 1947, Oklahoma A. & M. College. Farm background, 9 mo. field mapping, U. S. Corps of Engineers; 3 mo. Soil Conservation Service; 5 years commissioned war service; Corps of Engineers; currently teaching elements of field engineering. No physical defects. Available on 15 days notice. Married. Age, 30. Salary $3600. W-384

AGRICULTURAL ENGINEER desires work as manager of a plantation or large agricultural setup, either in U. S. or foreign country. BS deg in mechanical and agricultural engineering, University of California, 1940; requirements for MS deg in irrigation engineering, University of Wyoming, nearly completed. More than 2 yrs. teaching and research; 4 yrs. naval commissioned war service as engineering officer on diesel-electric destroyer. No physical defects. Available on reasonable notice. Married, age 30. Salary $4800. W-385

AGRICULTURAL ENGINEER desires service work in power and machinery field, with private company. BS deg in agricultural engineering. Enlisted commissioned war service in army motor maintenance. Currently employed as foreman in commercial freezing plant. No physical defects. Available on 60-day notice. Married. Age, 25. Salary $3000. W-386

AGRICULTURAL ENGINEER desires sales or production work in power and machinery field. BS deg in agricultural engineering 1946; in mechanical engineering, expected in 1947, University of Wisconsin. Farm background, one year mechanical and maintenance work with steel company. Unlimited steam marine engineers license. Enlisted and commissioned war service in U. S. Maritime Service. Amputation, one joint of middle finger, right hand. No interference with work. Available in September. Married. Age, 25. Salary $3500. W-387

AGRICULTURAL ENGINEER desires sales work in soil and water or power and machinery field. BS deg in agricultural engineering, Oklahoma A. & M. College expected in May. Over 5 yrs. enlisted and commissioned war service in field artillery. Additional experience as student assistant in agricultural engineering department. No physical defects. Available June 1. Single. Age, 29. Salary $3000. W-388

AGRICULTURAL ENGINEER desires sales, service, experimental or testing work with farm equipment manufacturer distributor. BS deg in agriculture with major in farm equipment expected in May, University of Wisconsin. Farm background including handling all types of farm machinery. War service in calvary and air corps. Part time employment while in school, in service work at Wisconsin General Hospital. No physical defects. Available June 1. Married. Age, 28. Salary open. W-389

AGRICULTURAL ENGINEER desires sales work in power and machinery, rural electrification, or farm structures. BS deg in agriculture, major in agricultural engineering, expected in May, University of Wisconsin. Experience part time sales, men's clothing, 9 yrs.; bookkeeper for motor sales and service, 9 mo.; commissioned war service, 5 yrs.; research fellow, dairy barn research project. 1½ yrs.. No physical defects. Available June 1. Married. Age, 27. Salary open. W-390

AGRICULTURAL ENGINEER desires extension or development work in rural electrification or soil conservation. BS deg in agriculture, with major in agricultural engineering, expected May, Macdonald College, Quebec, Canada. Experience 4 mo. irrigation work in British Columbia, 5 mo. extension work in rural electrification. No physical defects. Available May 15. Single. Age, 23. Salary $2400. W-391